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ON THE DIMENSIONS OF MOLECULES.

By Walter G. Woollcombe, M.A. (Oxon.), B.Sc. (Lond.).

THE two chief theories that have been held with respect to the constitution of matter are (1) that it is homogeneous and capable of infinite divisibility; (2) that it is heterogeneous with a finite limit to its divisibility. The former, propounded by Anaxagoras, accepted by Descartes, forms the basis of the philosophy of Spinoza. Though incapable of development it is useful as a working hypothesis up to a certain point. The latter theory was propounded by Democritus, elaborated by Lucretius, and, modified and refined in later times, is in some form or other accepted by all scientists at the present day. That matter cannot be homogeneous was shown by Cauchy,* who rendered it very probable that there could be no dispersion through a prism unless the ultimate limits of heterogeneity were comparable with the wave-lengths of light.†

According to the molecular theory, a body is made up of a great number of small particles or molecules, on the stability of which its properties depend. In a solid these particles are in a constant state of vibration about a mean position, being unable to pass outside the limits of attraction of their immediate neighbours. If we had a microscope of a sufficiently great magnifying power a solid body, as seen through it, would appear in a state of quivering agitation in consequence of this molecular motion. On gradually heating the solid, the energy of vibration increases until at last the molecules are able to break away from their neighbours, only, however, to come within the limits of attraction of other molecules. Their movements now may be compared roughly to those of children playing the game of "chain-ring," in which the chain is never broken, though each child is continually passing from one to another. The body is now said to be in a liquid state. On raising the temperature still further the energy of motion becomes so great that the molecules finally are able to separate from each other, and each pursues its own path. This constitutes the gaseous state, and is the simplest of the three; for we now have no longer to consider the mutual action, whether attractive or repulsive, between the molecules — Sir W. Thomson and Dr. Joule* having proved by experiments on the free expansion of gases that in a perfect gas (i.e. one far removed from its point of condensation) the internal work, done by the mutual action between the molecules, vanishes.

Daniel Bernouilli in the seventeenth century was the first to suggest that a gas consists of free particles in quick motion among themselves, and that the pressure on the vessel containing the gas was due to the agitation of these particles. In the hands of Clausius, Maxwell, and others this kinetic theory of gases has been so developed, and the results deduced from it agree so remarkably with experiment, that it is now, as Sir W. Thomson says, "accepted as a surest article of scientific faith." The assumption on which it is based is that the molecules are perfectly elastic spheres. Allowing this for the present, it is the object of this paper to point out the different methods by which the approximate size of the molecules has been calculated.

Considering the large number of them in a given volume of a gas† rushing about with velocities varying considerably on either side of the mean, it follows that they must be continually deflected from their paths by collisions‡ one with another. It is obviously impossible to isolate one of them; and to calculate its velocity, therefore, we must adopt the statistic method of averages, by which it can be shown that the molecules of a gas occupying a given volume can be arranged in three groups moving at right angles to each other with the average or mean velocity ω of the whole number. This mean velocity may be calculated thus. Let us take a volume V of a gas, and suppose N the number of molecules in this volume, and m the mass of each: then $\frac{N}{V}$ $(=n$, suppose) is the number of molecules in a unit of volume, say one cubic centimetre. Divide these into three groups, moving at right angles to one another with the mean velocity ω. There will, of course, be $\frac{n}{3}$ molecules in each group. Now each side of the cube has, after each encounter of a group, a force exerted upon it equal to twice the momentum of the group, assuming the side of the cube to send back the molecules with the same momentum with which they strike it. Therefore the momentum with which a group impinges on the side is $\frac{2\,m\,n\,\omega}{3}$. If the mean distance travelled by the molecules between two collisions is large compared with the diameter of the cube, the space traversed between two successive impacts on the same side of the cube would be 2 centimetres, and the time between these impacts $\frac{2}{\omega}$, therefore the number of impacts in a unit of time would be $\frac{\omega}{2}$. If the mean distance travelled between two en-

* "Mémoire sur la dispersion de la lumière."

† The wave-length of the D line in the spectrum is $5{\cdot}89 \times 10^{-4}$ millimetres. All physical constants used in this paper are taken from "Units and Physical Constants," by J. D. Everett.

* "Transactions of the Royal Society of Edinburgh," xx. p. 294.

† It has been calculated that one cubic centimetre of air at 0°C. and 76 centimetres pressure contains 6×10^{21} molecules.

‡ The number of collisions per second in air under the same conditions has been calculated to be nearly 5×10^9.

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counters is short compared with the diameter of the cube, these numbers will still remain unaltered; for the molecules, thrown back after collision, take the place of those that struck them. The pressure on the side of the cube, i.e. the momentum given it per unit of time, will therefore be

$$\frac{2mn\omega}{3} \times \frac{\omega}{2},$$

or

$$p = \frac{mn\omega^2}{3} = \frac{\rho\omega^2}{3}$$

where ρ is the density of the gas in question; therefore the mean velocity

$$\omega = \sqrt{\frac{3p}{\rho}}.$$

In order to get the velocity in centimetres per second, we have to substitute for the pressure p in absolute units. Let us calculate the mean velocity of hydrogen gas at 0°C, and under pressure of 76 centimetres of mercury. The mass of 76 cubic centimetres of mercury at 0°C is 76 × 13·596 grams. Multiplying this by 981·17, the value of the acceleration of gravity at Greenwich, we get 1013800 as the value of p in absolute units. The density ρ of hydrogen under these conditions is ·0000896. Substituting these values in the above expression, we find that the mean velocity of the molecules of hydrogen gas at 0°C and under 76 cm. pressure is 184250 centimetres per second—that is, about 69 miles per minute. For air under the same conditions of temperature and pressure, we should find ω to be about 18 miles per minute.

The distance a molecule travels between two collisions is called its free path. The average or mean free path, λ, of all the molecules of a given gas, under stated conditions of temperature and pressure, has been calculated by Graham* and Loschmidt† from experiments on the diffusion of gases; by Meyer‡ and Maxwell§ from experiments on viscosity or internal friction of gases; and by Stefan‖ from experiments on the conduction of heat in gases. These three different methods give remarkably consistent results considering the extreme difficulty of the experiments, and tend to show that the mean free path of molecules in hydrogen gas at 0°C and under 76 cm. pressure is about 16×10^{-6} cm., and for air under the same conditions about half as long.

Clausius¶ has by a beautiful theorem shown that the

$$\text{diameter of a molecule} = \frac{8 \text{ times the bulk of the molecules}}{\text{volume occupied by the gas}} \times \lambda.$$

Loschmidt in 1865 was the first to give a numerical estimate of the size of the molecule by the above method. Taking a volume V of an easily condensible gas, he determined accurately its density. He then liquefied it, and determined the density of the liquid. Assuming that in the liquid form the molecules are in contact with each other,** the latter result gives us their bulk, and knowing λ from the experiments made on diffusion, he calculated the diameter of a molecule from the above equation. Meyer†† theoretically deduced from the kinetic theory that the coefficient of viscosity of a given gas is equal to $\frac{C}{n\pi r^2}$, where C is a constant determinable for the gas, r the radius of a molecule, and n the number of molecules in a unit of volume. If by experiment we determine the value K of this coefficient and equate it to the above quantity, we get $n\pi r^2 = \frac{C}{K}$, a known number. Now $n\pi r^2$ is four times the sum of the great circle areas of the molecules in a unit of volume, and from this we can determine the radius r. Not much importance, however, can be given to a deduction based purely on mathematical analysis.

Van der Waals* took as his starting point the variations in the expansion of gases. Take a volume V containing N_1 molecules, each of mass m, exerting a pressure P_1, and introduce N_2 more of the same kind of molecules; suppose the pressure to become P_2. Supposing the temperature to be constant, the final pressure would be increased in the ratio $\frac{N_1 + N_2}{N_1}$, if the gas followed Boyle's Law exactly.† But if r is the radius of a molecule, the bulk of the N_1 molecules is $\frac{4}{3}\pi r^3 N_1$, and the volume occupied by the second batch would be less than V by this quantity; therefore the final pressure is greater than it should be, and there is a small deviation from Boyle's Law. Knowing this deviation for a particular gas from Regnault's experiments on the compressibility of gases, the value of r was determined.

The three methods alluded to above depend upon the Kinetic Theory of Gases, and point to the conclusion that the diameter of a molecule must be greater than 2×10^{-8} millimetre. The remaining two methods, which we shall give next month, are based upon the principle of the Conservation of Energy, and were first described by Sir W. Thomson—one of them depending on capillary phenomena, the other upon the electric attraction between zinc and copper plates.

(To be continued.)

* "Edin. Phil. Trans.," xii. p. 222.

† "Beiträge zur Grösse der Luftmolecüle," *Wien. Akad. Sitzungsb.* Band lxi.

‡ "Kinetische Theorie der Gase."

§ "Phil. Trans.," 1867.

‖ "Wien. Akad. Sitzungsb.," lxv.

¶ By the theory of probabilities, Clausius deduced that the mean free path of a molecule of a gas was equal to $\frac{3}{4\pi n d^2}$, where d is the diameter of a molecule, and n the number in unit volume. From this the above equation is easily deduced. Van der Waals, Die Continuität des gasformigen und flüssigen Zustandes.

** This is not a legitimate assumption: this method, therefore, gives too high a result.

†† *Loc. cit. supra.*

* Van der Waals, *loc. cit. supra.*

† By Boyle's Law $\frac{P_2}{P_1} = \frac{D_2}{D_1}$ where D_1 and D_2 are the densities of the gas in the initial and final states, but $D_1 \propto mN_1$ and $D_2 \propto m(N_2 + N_1)$ $\therefore \frac{P_2}{P_1} = \frac{N_2 + N_1}{N_1}$.

THE TRANSFORMATIONS OF SAWFLIES.

By E. A. Butler.

In its adult condition, a sawfly will feed chiefly upon pollen or upon the small insects, especially minute beetles, which frequent flowers. But during its larval life, its food consists of the leaves of trees and plants. Amongst trees, willows and poplars are most affected, and of smaller plants, the orders *Ranunculaceæ*, *Umbelliferæ*, *Rosaceæ*, and *Compositæ* support the largest number. The mother insect, therefore, when she wishes to deposit her eggs, seeks out a tree or shrub of the proper species, and, settling on a leaf, proceeds to make the necessary arrangements for securing the safety and maintenance of her expected brood. The exact details of the process of course depend upon the species, for the greatest possible variety is observable in such matters as the number of eggs laid per leaf, the position in which they are placed, and the nature of the nidus prepared—all of which, judging from

the constancy of the arrangement in specific instances, one must suppose to be matters of some importance to the well-being of the insect.

The eggs may either be situated in hollows formed by the mother for their reception, or be merely glued to the surface of the epidermis of the leaf, the former being the usual method. Taking up her position so that the extremity of the abdomen is over the point to be attacked, the female sawfly pushes out her saws (fig. 1), at the same time inclining them so that they form an angle with the body; then, holding on tightly with her feet, she begins to work

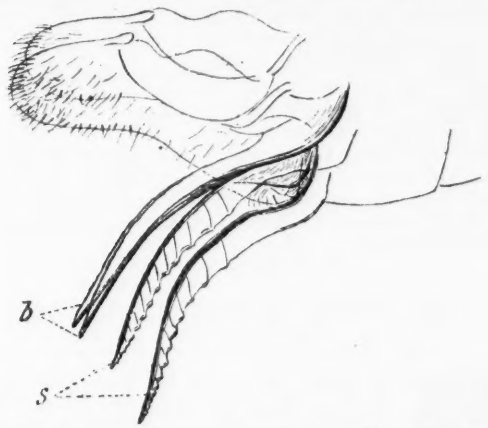

Fig. 1.—Saws of Sawfly; *s*, saws; *b*, backs. The figure is taken from a specimen mounted for the microscope, and the saws have therefore become separated from one another, and from their respective backs.

the saws backwards and forwards upon the place selected, till a slit is formed. Then an egg is passed down to the spot, the saws themselves serving as guides to direct it to its resting-place. At the same time a drop of an irritating liquid passes from a gland at the base of the saw (apparently the analogue of the poison gland of bees and wasps) and enters the slit, producing a morbid action there which causes it to gape more widely, and prevents the egg from being inclosed and crushed. Very soon the egg, in a way not satisfactorily understood, undergoes a remarkable increase in size, and after a while, a little grub issues from it, and begins to devour the leaf which has cradled it. Sometimes the irritation caused by the poison is so great that a large morbid growth of the leaf results, forming a gall which incloses the caterpillar. The oval red gall so frequently seen on willow leaves is a familiar instance of this.

The caterpillars remind one very forcibly of those of the Lepidoptera, and are by amateurs frequently mistaken for these. That there should be such a resemblance is not surprising, since both, speaking generally, live on the same kind of food, and get it in the same way; and the form of a larva is determined a great deal more by the character of the food and the method in which it is obtained than by the nature of the perfect insect it is to develop into. Notwithstanding the similarity, however, a sawfly caterpillar can usually be readily distinguished by attention to one or two little details. In the first place, its legs are more numerous than those of a lepidopterous larva, or rather, this is the case with the substitutes for legs situated on the hinder part of the body; for, like the caterpillars of moths, sawfly grubs have three pairs of strong, curved, sharp-pointed legs in front, which correspond with the three pairs possessed by the adult. In the hinder part of the body, however, there is a series of fleshy protuberances in similar positions to the claspers or prolegs of a lepidopterous caterpillar; but there is this difference: between the claspers and the true legs of the caterpillars of butterflies and moths there are always a number of segments without legs of any kind, but in those of sawflies the prolegs succeed the true legs either immediately or with a very slight interval, and are continued to the end of the body. Though more numerous, however, they have not the tenacity of grip which those of an ordinary caterpillar possess in consequence of the recurved hooks round the rim. So powerful are the prolegs of a lepidopterous caterpillar in this respect that the insect frequently assumes a position of rest in which the fore part of the body is elevated, and clings to its support by the claspers only. A sawfly larva's chief holding power, on the other hand, resides in the curved claws in front, and often the *hinder* part of the body remains quite unattached to the leaf, being either coiled round or elevated in the air (fig. 2).

Fig. 2.—Sawfly Caterpillars devouring a leaf, showing characteristic attitudes.

These caterpillars have many enemies, but at the same time many means of protection. Ichneumon flies, the bane of leaf-eating grubs in general, make no exception of those of sawflies, and many species prey upon them, and thus no doubt greatly reduce their numbers. There are some dipterous flies too, something like our common house fly, whose maggots are internal parasites of these insects. The hinder part of the caterpillar's body, elevated in the air as above described, and whisked about from side to side, forms an excellent apparatus for whipping away all such winged assailants. The colours, again, frequently harmonise with the surroundings, green being by far the commonest, and thus many species are screened from molestation. But sometimes the reverse is the case; the colours are bright and very conspicuous, as *e.g.* bright orange, and the insects are easily seen; in such instances the protection takes the form of an unpleasant secretion, which either makes them distasteful morsels, or yields a disagreeable odour sufficient to warn off intruders. In such species the bright colour is a sort of danger signal, warning insectivorous birds that the pretty things are not desirable articles of food. The slug-worms of the pear and plum trees are so called because the body is covered with a slimy secretion which renders them particularly repulsive in appearance, and when many are feeding together a sickening odour is perceived which still further insures them immunity from attack.

Another means of defence consists of an acid liquid secreted in little glands just beneath the skin, and capable of being ejected through minute openings along the sides; this is particularly noticeable in some of the larger species, which, when touched, squirt out the liquid to some distance and with considerable force. A stiff, whitish green caterpillar, which commonly occurs on hawthorn bushes, is probably the best known illustration of this. Of course, as with other secretions, the supply of this liquid is limited, and after a few discharges becomes exhausted; but a period of rest soon replenishes the stock. Many of those species that feed on low plants readily take alarm, and drop to the ground at the approach of danger, coiling themselves up in a circle or a spiral, and remaining motionless amongst the roots of the herbage till circumstances permit them to climb

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the leaves again and recommence feeding. Others, again, feed by night, and thus avoid many risks.

Before changing to a chrysalis, the grub has to select a suitable spot in which to spend its pupal life. This will often be in a very different locality from that in which its life has hitherto been passed. Instead of the leaf of the food-plant, its sole abode till now, a hollow stem may be required, or a hole made in a tree by some burrowing insect; or again, it may be necessary for the grub to enter the soil and there excavate a subterranean chamber to accommodate it till it shall reach its final condition. In going in search of such localities, the larva may have to travel some distance, and in the course of its wanderings will probably enter upon new scenes and strange surroundings, and will therefore, in all likelihood, encounter unaccustomed dangers, to guard against which its present aspect is not well adapted. Hence a remarkable change frequently takes place in its appearance at its last moult, and it is sometimes so much altered as not to be recognisable as the same insect. Thus the slimy slugworms, of bottle-green colour in their early life, lose at their last moult all the sliminess, and become dry and orange-brown, whereby they are better adapted for descending to the ground to spin their cocoon.

When the insect has constructed its cocoon, it remains quiescent for some days before the next moult exhibits it as a chrysalis. Those, however, which construct their cocoons in the autumn live therein as larvæ through the winter, and do not therefore actually effect the change into the pupa till the following spring, remaining till then in a torpid condition, so that actually the longest part of their larval life is spent in this inert state. Though resembling the Lepidoptera in their larvæ, sawflies are truly hymenopterous in the character of the chrysalis, which, like that of a bee, reveals all the limbs and appendages of the perfect insect, covered only by a thin skin (fig. 3). Green is a common colour for the insect in this stage of its career. The pupal stage is not a long one, and in barely a fortnight's time from its commencement the insect may be expected to make its final moult and appear as a winged creature. But it will even then remain within the cocoon until its skin has hardened, when it will cut off one end of its silken shroud and thus make its exit.

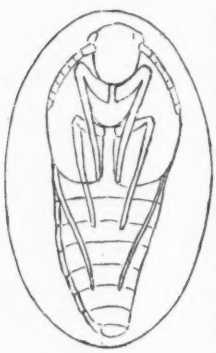


Fig. 3.—Pupa of Sawfly in the Cocoon (somewhat diagrammatic)

May and June are the chief months for the appearance of the perfect insects, and in some cases a second brood appears in July and August. When the leaves are young and tender, the flies may be seen walking about amongst them seeking suitable places for oviposition. They are not very active nor strong on the wing, and their flights are therefore but of brief duration, so that there is very little difficulty in capturing them. In the weakness of their flight they present a marked contrast to many other hymenopterous insects, notably the bees, which, for vigour and rapidity of movement, easily carry off the palm. The eggs of sawflies are placed in a great variety of positions; they may be simply scattered at random over the area of the leaf, or placed regularly and methodically either round the edge or along the veins, or again, they may be deposited on the leaf-stalk. Some species are extremely prolific, and, if they should happen at the same time to be gregarious, much damage may be done to vegetation. The common pest of the gooseberry and currant bushes (*Nematus ribesii*) is an example of a gregarious species; it lays its eggs on the under surface of the leaves by the side of the veins (fig. 4), and sometimes in such numbers that upwards of a thousand have been observed on a single gooseberry bush. The turnip sawfly (*Athalia spinarum*), another gregarious and very destructive species, lays its eggs close to the *edge* of the leaf, and great multitudes are produced, one female being capable of becoming the parent of from two to three hundred. Some species, if disturbed, "sham dead"—*i.e.* they instantly fold their wings together, pack their legs up close to their bodies, and drop to the ground, where they escape observation by lying motionless like little rolls of earth. As perfect insects they do not live long; their one business is the perpetuation of their kind, and the females die immediately after oviposition.

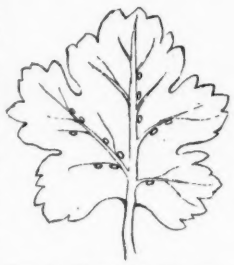


Fig. 4.—Eggs of *Nematus ribesii* on Gooseberry Leaf.

THE SUN'S MOTION IN SPACE.

By Maxwell Hall, M.A., F.R.A.S.

In a paper read before the Royal Society on March 6, 1783, and published in the "Phil. Trans.," vol. lxxiii., Sir William Herschel announced the motion of the solar system in space towards a point in the heavens near the star λ Herculis, with a velocity probably exceeding six times the distance of the earth from the sun per annum; and the importance of the subject has led to as many as fifteen separate and arduous investigations by some of the most eminent astronomers of the present century, which all confirm the direction of the motion, but yield varying results with regard to its amount. Thus the position of the solar *apex*, or point in the heavens towards which the sun moves, is Right Ascension 261°, North Polar distance 64°, according to Sir William Herschel's original sketch. A careful selection of several of the subsequent results made a few years ago gave R.A. 260°, N.P.D. 56°; while Herr L. Struve, who has recently published an investigation, adopts R.A. 267°, N.P.D. 59°, as a general result deduced from all the preceding computations.

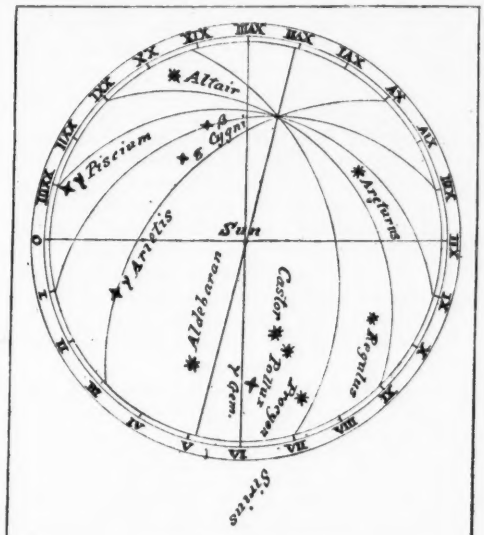
While further confirmation is quite unnecessary, further computation is still required to meet the ever-increasing demand for accuracy, and a few remarks on the general aspect of the problem may prove interesting to our readers.

In the figure on p. 121, taken from the original article of Sir W. Herschel, the plane of the celestial equator coincides with the plane of the paper, the spectator is supposed to look down upon the North Pole, and the sun is situated at the centre of the sphere. Now if the sun move towards the apex marked by the intersection of the arcs of the great circles, the stars will apparently move *from* the apex in directions indicated by arcs of great circles drawn through their places and the apex itself. Arcturus, for instance, will apparently move so that the R.A. of that star will decrease, while the N.P.D. will increase; but Aldebaran will apparently move so that both the R.A. and N.P.D. will increase, and so for the other stars. Sirius happens to be on the southern side of the celestial equator, and can hardly be placed in the figure.

Sir W. Herschel considered only the thirteen stars given; and if we employ the more accurate proper motions of these

stars which have been deduced in recent years, we shall find that of the twenty-six motions in R.A. and N.P.D. as many as twenty are in accordance with the theory as far as direction of motion is concerned.

The discrepancies between the observed proper motions and what may be due to the sun's motion in space chiefly



THE SOLAR APEX.

refer to the true motions of the stars themselves, which in these investigations may be regarded as utterly irregular. But a third element enters into the composition of proper motions as given in our star lists, namely, errors of observation; and in dealing with 2,000 or 3,000 stars,* many of which have very small proper motions, we have reason to fear that the increase in the number of stars employed by no means implies an increased accuracy in the results. Of course these errors of observation are theoretically supposed to disappear from the final equations, exactly as the true motions of the stars disappear, leaving a balance due to the sun's motion in space; but clearly there must be a limit to the accuracy obtainable under such circumstances.

In the "Memoirs" of the R.A.S., vol. xxviii., there is a very important article on the subject by Sir George Airy. No previous assumption is made as to the probable position of the apex in order to introduce equations whose solution would give the required correction of the assumed position, but the problem is so conducted that the balance of motion due to the sun's translation in space is directly deduced so as to give the direction of this motion and its angular amount in one year, as seen at right angles to its direction from a distance equal to that of an average first-magnitude star. Ordinary errors of observation are considered, as well as systematic errors; the latter may be due to Bradley's instruments, for it is from Bradley's observations in the last century that the proper motions of the stars are found by comparison with recent observations; or they may be due to the constants of precession employed in the comparison. The probable error of the proper motion of each star due to ordinary errors of observation is assumed to be the same; but as it will appear that the problem separates the brighter and fainter stars, this assumption requires reconsideration; for there can be no doubt that the positions of the brighter stars were far more accurately ascertained by Bradley than the positions of the fainter stars. Another source of doubt will be found in the assumed connection between stellar magnitudes and distances, to which it will be necessary for us to refer again.

The problem is then conducted on two suppositions:—(i.) That the differences between the observed proper motions and what may be due to the sun's motion in space refer to errors of observation; (ii.) that these differences refer to the actual motions of the stars themselves.

The results for the position of the solar apex and the velocity of the solar motion are—

	i.	ii.
R.A.	257°	261°
N.P.D.	51°	65°
Ang. vel.	1″·3	1″·9

If we assume the parallax of an average first-magnitude star to be 0″·1, we must multiply the angular velocity by 10 (and remove the marks indicating seconds of arc) in order to obtain the linear velocity of the sun in radii of the earth's orbit per annum; so that according to (i.) the velocity is 13, and according to (ii.) the velocity is 19 radii of the earth's orbit per annum.

Again, on supposition (ii.) the sum of the squares of the stellar motions employed is reduced from 102 to 94 in consequence of this motion of the sun in space.

But the most remarkable feature of this investigation is the circumstance that according to (i.) the results depend on the brighter stars, and according to (ii.) the results depend on the fainter stars; so that clearly a third supposition should be made in order to combine (i.) and (ii.) according to their probable weight, and so to distribute the work among all the stars employed.

In this investigation 113 stars having large proper motions were employed, and the calculations were performed by Mr. Edwin Dunkin. In vol. xxxii. of the "Memoirs" of the R.A.S. Mr. Dunkin extended his calculations so as to include 1,167 stars, which are nearly all the stars contained in Mr. Main's lists of proper motions.

The following are the results:—

	i.	ii.
R.A.	261°	264°
N.P.D.	57°	65°
Ang. vel.	0″·33	0″·41

And on supposition (ii.) the sum of the squares of the stellar motions employed is reduced from 142 to 136.

In vol. xlvii. of the "Memoirs," Mr. W. E. Plummer applied the same formulæ to 274 southern stars taken from Mr. Stone's Cape Catalogue for 1880. The following are the results:—

	i.	ii.
R.A.	281°	270°
N.P.D.	64°	70°
Ang. vel.	0″·77	1″·7

And on supposition (ii.) the sum of the squares of the stellar motions employed is *increased* from 173 to 179.

Now as this last result was very unsatisfactory, and as it was apparently due to a few small stars having very large proper motions, Mr. Plummer reconsidered the problem by abandoning the connection between magnitudes and distances, and by adopting a connection between proper motions and distances. Whence

	ii.
R.A.	276°
N.P.D.	63°
Ang. vel.	0″·93

* Herr L. Struve employs the proper motions of 2,509 stars, deduced from the observations of Bradley as recently reduced by Dr. Auwers; he uses Sir G. B. Airy's formulæ, and adopts the same assumed connection between magnitude and distance. His results correspond with those of Mr. Dunkin, but from what follows, it is to be doubted whether they are more accurate.

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and the sum of the squares of the stellar motions employed is reduced from 173 to 110.

We are therefore led to inquire what would be the effect on Mr. Dunkin's work if this connection between proper motions and distances were adopted instead of the connection between magnitudes and distances; and in order to determine this important point it would be better to recompute the first series, containing 113 stars having large proper motions, rather than the second and larger series containing 1,167 stars; the recomputation should be based on supposition (ii.), and the same proper motions should be used as in the first computation by Mr. Dunkin.

Should the result be favourable, a connection should then be adopted between magnitudes, proper motions, and distances; and an investigation based upon the combined suppositions (i.) and (ii.), and the proper motions of the best observed stars, could not fail to advance towards the accuracy we require. Such proper motions will be found for 622 stars in Dr. Auwers' Fundamental Catalogue of Stars for Zone Observations; and they might be supplemented by a few of the best-observed stars in the southern hemisphere.

In short, we should use the excellent systematic work briefly referred to above to guide the course of future investigation; and though such work is laborious, yet it is of vast importance, and forms but the opening chapter of much that is probably opening up to us respecting the great sidereal motions; for no one can suppose that those motions which at present seem to us to be utterly erratic are really so, and that harmony prevails only in the solar system.

In the present state of our knowledge we may affirm that Sir W. Herschel was perfectly correct in saying that the sun and its attendant train of planets is moving towards a point in the heavens near λ Herculis with a velocity of six or eight times the distance of the earth from the sun per annum, or with a velocity of eighteen to twenty-four miles per second.

This velocity compares favourably with the known velocities of other members of that class of stars to which the sun probably belongs. There are other stars, such as 1830 Groombridge and 9352 Lacaile, which have much higher velocities, and there are of course other stars which have much smaller velocities; but we cannot enter at present on the subject of stellar velocities, which are dependent on the results obtained by the spectroscope for velocity in the line of sight, as well as on results deduced from their motions at right angles to the line of sight; it is sufficient for us to have pointed out the importance of following up Sir George Airy's researches, which are independent of the spectroscope, in order to obtain the sun's motion in space with as much accuracy as may be possible.

BATS.

By A. J. Field.

MOST people have seen bats flitting hither and thither in the twilight on a warm evening, and some of my readers will remember their shrill cries. But it is not every one who can hear bats cry, for their note is so high that to many people it lies beyond the limit of audible sounds. The human ear can only hear sounds which lie within a certain number of octaves. There are some sounds too shrill and some too low to be heard, and every one's ears have not the same limit of sound sensation any more than their eyes have the same limit of light perception at the two ends of the spectrum. The bat has an interesting geological history; fossil remains of many species are found in the Eocene and later Tertiary deposits, and at the present day over one hundred and thirty species are known, some of which have a very wide geographical distribution. The larger species inhabit tropical countries, and smaller bats are to be found as far northward as latitude 60°. Some fifteen species are found in Great Britain. One of the most common is the long-eared bat, shown in the accompanying illustration, fig. 1 (*Plecotus auritus*).

This bat is extensively distributed over the greater part of Europe and Northern Africa, and is found in the East throughout Central Asia, but not south of the Himalayas. It is quite common in the neighbourhood of London; but though so abundant, it is perhaps not so often seen as other species, for it appears on the wing later than other bats, and remains out the whole of the night, while many of the other bats return to their haunts when complete darkness has fallen. Its ears vary from an inch to an inch and three quarters in length, and they have a fold in them reaching almost to the tips. It is owing to this most peculiar structure that the name *Plecotus* * has been given to the genus to which this bat belongs.

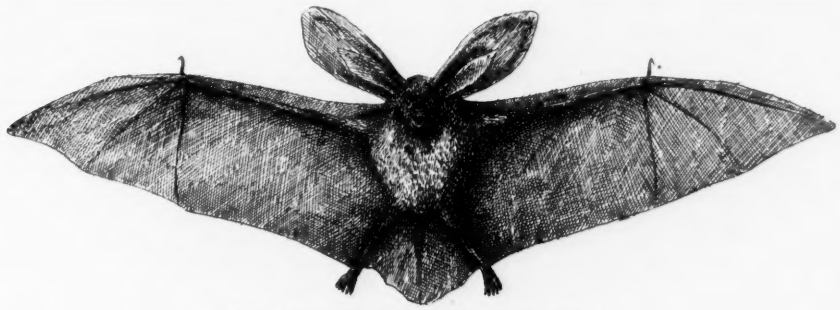
Bats are not blind, as is commonly supposed, but their eyes apparently play only an insignificant part, as compared with their ears, in directing them in pursuit of the moths and insects on which they feed; indeed, experiments made by Spallanzani show that blinded bats can avoid obstructions with as much ease as bats possessing their full eyesight. What is it that the long-eared bat needs his great ears for? Perhaps the editor of Knowledge will excuse me if I indulge in a little speculation which cannot be put forward as definite knowledge. Mr. Francis Galton has tested, by means of a little specially contrived whistle, the limits of the sound spectrum which affects the ears of various animals in the Zoological Gardens; and, as a general statement, it may be said that animals speak or roar in about the middle octave of the sound spectrum to which their ears are sensitive. The bats speak in a very high note. We may probably therefore assume that they hear still higher sounds. The larger mammalia as a rule utter bass notes, and the smaller mammalia shriller sounds. We are perhaps not making a very wild assumption if we suppose that the moths and night-flying insects communicate with one another by means of still shriller sounds, which fall unheard upon our ears, but which the long-eared bat listens for keenly with his great ears. The colour of the fur of bats varies with their age. Our own British long-eared bat is usually of a reddish or greyish-brown tint, the hair being blackish at the base. Those from North Africa, and from the desert regions near the Mediterranean and Caspian Seas, are generally described as having the fur paler and more ashy in colour.

The long-eared bats that I have had in my possession appeared rather dull and listless in their manner, and were altogether less interesting than any other pet I have had. Perhaps this may be due to the fact that I did not catch them when young, for many naturalists say that the long-eared bat in captivity soon becomes very tame. Professor Bell describes a long-eared bat in the possession of Mr. James Sowerby, which would fly to the hand of any of the young people who held up a fly towards it, and resting upon the hand, take the fly without any hesitation. If the insect was held between the lips, the bat would then settle on the child's cheek, and take the fly with considerable gentleness from the mouth; and so far was this familiarity carried, that when either of the young

* From the Greek πλέκω, I fold; and οὖς, an ear.

people made a humming noise with the mouth, in imitation of an insect, the bat would search about the lips for the promised dainty.

The long-eared bat is not so graceful on the wing as other bats, but when on the ground its mode of progression is simply grotesque; it rarely resorts to this method of locomotion if it can avoid it. When doing so, it seems to carry the fore part of its body just slightly raised, and advances by a series of spasmodic jerks, first on one side and then on the other. Many of the other bats move more readily over the floor, and may almost be said to walk.



The Long-eared Bat (*Plecotus communis*).

Gilbert White,* in a letter written in 1767, gives a most interesting account of a tame bat he had in his possession. He writes: "I was much entertained last summer with a tame bat, which would take flies out of a person's hand. If you gave it anything to eat, it brought its wings round before the mouth, hovering and hiding its head in the manner of birds of prey when they feed. Insects seemed to be most acceptable, though it did not refuse raw flesh when offered; so that the notion that bats go down chimneys and gnaw men's bacon, seems to be no improbable story. While I amused myself with this wonderful quadruped, I saw it several times confute the vulgar opinion that bats when down upon a flat surface cannot get on the wing again by rising with great ease from the floor. It ran, I observed, with more dispatch than I was aware of, but in a most ridiculous and grotesque manner." This bat was *not* one of the long-eared species. By many people the long-eared bat is regarded as being strictly insectivorous, but this appears to be inaccurate, for several of my bats were very fond of honey, over ripe fruit, and even raw beef when cut up finely.

The long-eared bats generally bring forth not more than two little ones at a time, and, being mammalians, the females suckle their young until they are old enough to find food for themselves. It is interesting to note the active circulation of the blood in the wings of the bats belonging to this family *Vespertilionidæ*.† The nervous system is also highly developed in their wings, which explains the marvellous sensitiveness displayed by them when on the wing, and their power of avoiding objects in the dark or when blinded. The long-eared bats, in common with various other species, fly with great rapidity, and they often rise to a considerable height in the air. It is doubtful whether they feed in the daytime. I have often seen them on the wing in broad daylight, and even in the heat of the sun. Their day flight is analogous to that of the night time, but whether they are hunting or only taking flight on having been disturbed in their retreat is difficult to determine. They pass the winter, and indeed the greater part of the year, in a state of torpidity, collecting in great numbers and suspending themselves by their hinder limbs. When thus suspended its long ears are tucked under its wings, which cover the greater part of the body; the pointed membrane inside the ear is then visible, and might be taken to be the actual ear itself. The dentition of the long-eared bat is—incisors, $\frac{2-2}{6}$; canines, $\frac{1-1}{1-1}$; pre-molars, $\frac{2-2}{2-2}$; molars, $\frac{3-3}{3-3}$. Its toes are more than half the length of the whole slender little foot, and the tail is equal in length to the head and body. In the illustration, figure 2, we have an excellent drawing of the Greater Horseshoe bat (*Rhinolophus ferrum-equinum*); this and an allied species, the Lesser Horseshoe bat (*Rhinolophus hipposideros*), are also inhabitants of Britain, but both are much rarer than the long-eared bat. The term horseshoe is applied to this genus owing to the circumstance that their noses are pro-

The Horseshoe Bat (*Ferrum equinum*).

* "Natural History of Selborne," page 39, in the "Chandos" edition.

† Sometimes termed the family of true bats.

vided with leaf-like membranous appendages of complicated structure, the front part of which in appearance is fancifully supposed to be something like a horseshoe. This somewhat curious modification of the nose renders the whole head of the bat very conspicuous, and has given rise to many superstitions respecting it. The ears of the Greater Horseshoe bat, which are generally of a pale brown colour, are large and somewhat broad at their base; they are pointed at the tip, and turned outwards. We would also call the attention of the reader to the fact that, unlike the long-eared bat, there is no tragus or pointed membrane inside the ear of this species. It has the full number of teeth commonly developed in the family, viz., incisors, $\frac{2}{4}$; canines, $\frac{1-1}{1-1}$; pre-molars, $\frac{2-2}{3-3}$; molars, $\frac{3-3}{3-3}$. The second lower pre-molar is generally situated outside the teeth-row, while the first upper pre-molar is either in the teeth-row, or else lying in the outer angle between the somewhat approximated canine and the second large pre-molar.

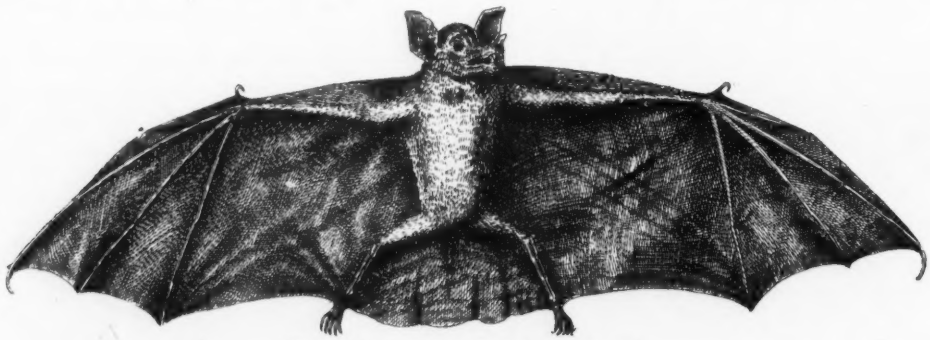
The Greater Horseshoe bat feeds chiefly on coleopterous insects. I have examined the stomachs of several specimens which have been sent to me for dissection, and fragments of beetles seemed invariably to form the greater portion of the undigested contents of their stomachs. Although the teeth of the Horseshoe bats are more adapted for this food than those of many other bats, it is difficult to understand how these delicate little creatures can crush the hard cases of the Stag-beetle, the Water-beetles, and the Watchman-beetle, parts of which I have occasionally found amongst a mass of other débris in their stomach. Although rare in England, the Greater Horseshoe bat has a wide geographical distribution. In Europe it extends from Spain and Portugal to Greece and Turkey, and is to be found as far northward as Central Germany and Southern Russia. It also inhabits Asia and Africa. It was originally discovered as an English species at Dartford in Kent, but it has also been found at Margate, Rochester, Bristol, Colchester, Clifton, and the Isle of Wight. The Horseshoe bats hybernate at a temperature varying from about 40° to 55°, and during the complete state of torpidity no pulsation whatever can be detected; they seem to recover animation at a heat of about 70°.

The illustration, fig. 3, is a fairly good representation of the famous Vampire bat (*Vampirus spectrum*), which is one of the most inoffensive of animals. It does *not* subsist upon blood of the sleeping traveller, but is a harmless vegetarian.

The Desmodus is perhaps the only real blood-sucking bat in South America. My friend Mr. Cotton tells me that while travelling in Chili, he once caught one in the act of biting his horse.

Those who have seen the Fruit bats in the monkey-house at the Zoological Society's Gardens may have noticed their strange mode of walking. They close their wings, which then do service as if they were fore-feet. The hook of one thumb is fixed to some object—generally the wires of the cage, and by it the body is pulled forward on one side, the next step being performed by the other hook on the left thumb. At present there are two kinds of fruit-eating bats in the Gardens—the Indian fruit bat (*Pteropus medius*) and the Collared Fruit bat (*Cynonycteris collaris*). They are very playful, curious, and quarrelsome, and have a wonderfully intelligent and observant look, which strongly reminds one of their near relations—the monkeys. When handled the Fruit bats bite viciously, but Mr. Bartlett tells us that some tame African species he had in his possession would crawl about him, and even lick his face and hands.

Some bats, both English and foreign, are infested with a well-known human parasite which fortunately does not often trouble domestic animals or even monkeys. I refer to the insect commonly called the "Norfolk Howard." I have frequently found them on dead bats; sometimes the fur is said to be swarming with them, though I have never found more than five or six on one individual. Bats are probably sometimes guilty of introducing these troublesome creatures into cottages and houses, where there is shelter under the thatch or in chimneys. But it may comfort careful housewives to be told that cockroaches, if sufficiently encouraged, will rid a house of the visitors the bats may bring. My friend Mr. Cotton has taken advantage of this fact, and has for some weeks past kept a bat so infested in company with a large tame East Indian cockroach. The bat has not attempted to interfere with the cockroach, and allows it to walk over its body. I have seen the cockroach seize and devour one of its neighbour's pests, which had fallen to the ground.



The Vampire Bat (*Vampirus spectrum*).

OUR COAL SUPPLY.

In a paper recently read at a meeting of the Statistical Society, Mr. R. Price-Williams quoted figures tending to show that, in view of the average increased rate of output during the last twenty years, our coal supply may be expected to fail after the following periods, unless the pits are worked to greater depths than is at present possible:—Lancashire and Cheshire, 74 years; Nottingham, Derbyshire, and Yorkshire, 90 years; South Wales, 79 years; North of England, 94 years; South Wales (Eastern division), 46 years; Warwickshire, 53 years; North Wales, 250 years; Scotland, 92 years; and other districts (Great Britain), 102 years.

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1.—Looking North from Mount Hamilton.

2.—General View of Lick Observatory and Out-buildings.

3.—Stage leaving Central Door of Observatory.

4.—Lick Observatory as seen from East Peak.

MOUNTAIN OBSERVATORIES.

By A. C. Ranyard.

THE photographs reproduced in the plates are selected from a packet of paper photographs, which Mr. Burnham has been kind enough to send me, to show, as he modestly puts it, the progress he is making in photography, and to give some idea of his surroundings at the Lick Observatory. I hope that in future numbers we may be able to reproduce for the readers of Knowledge some other photographs from this interesting packet.

It was owing to observations made by Mr. Burnham on Mount Hamilton with a six-inch telescope in the autumn of 1879, that the site of the Lick Observatory—4,200 feet above the sea-level—was chosen by Mr. Simon Newcomb and his co-trustees of the Lick funds, as the most suitable, though certainly not the most convenient, place to build a great Observatory.

The large telescopes at present in use have increased the difficulty which astronomers have always laboured under of obtaining sharp definition of the objects they observe outside the atmosphere. We live under an ocean of air, which is not perfectly transparent, and is never perfectly uniform or still. The slight differences of temperature of ascending and descending currents, and probably also slight differences in refractive power of masses of air charged with differing amounts of aqueous vapour, cause small deviations in the course of a ray of light which passes through the atmosphere to the telescope, and ultimately to the eye of the observer.

If the air was perfectly still, and the earth was not in motion about its axis, these slight deviations in the course of the ray would be of comparatively little importance, but, owing to the rotation of the earth, the line along which a ray of light from a star comes to us, moves slowly through the atmosphere like the hand of a great clock which goes round the clock face once in twenty-four sidereal hours, the observer's eye forming the pivot about which the path of the light ray turns. Near to the observer the motion is, of course, very slow, but at a distance of twenty-five miles it would move through the atmosphere, if there was no wind, at a rate of nearly 10 feet a second. The different coloured rays of light which go to make up the white image of a star have followed different paths through the atmosphere, unless the star is in the region vertically over the observer's head. The red light has entered the atmosphere at a point lower down (that is, nearer to the observer's horizon) than the blue light, for the atmosphere acts as a prism, and the blue ray is more refracted than the red. If we trace backwards to the limits of the atmosphere the rays which enter a telescope—say of two feet in diameter, directed towards a star at an altitude of 45° above the horizon—we must picture to ourselves a number of slightly bent cylinders of light rays arranged fan-wise, the upper radii of the fan being blue and the lower red. The fan of coloured rays sweeps slowly round the observer as the star rises or sets, and fresh masses of differently refracting air are brought within it, which slightly vary the course of the different coloured rays and cause momentary changes of colour or scintillation. A phenomenon which was noticed by the observing little child imagined by Doctor Watts, who rather precociously, as I have always thought, wondered what the star was, and must no doubt have wondered how the twinkling of the diamond in the sky was caused.

If the spectrum of a rising or setting star is observed with the spectroscope, it will be seen that dark bands, corresponding to the coloured rays which are dimmed or cut out, sweep slowly along the spectrum as the masses of refracting air are carried from the blue to the red end of the fan, or *vice versâ*, causing a dispersion or concentration of the light of the different coloured images much in the same way as the light ripples are caused which may be seen sweeping along at the bottom of shallow water on a sunny day, when the surface of the water is disturbed by little waves. If only one coloured ray from a star reached us, the coloured image would not only increase and decrease in intensity, but its place would slightly shift or dance about. What we observe with the naked eye, or with a telescope, is the combined effect of the dancing and alternately brightened and dimmed coloured images on the retina. The larger the aperture of the telescope used, the greater is the volume of the atmosphere which affects the light received by the eye, and the greater will be the number of disturbing masses which sweep across the path of the light entering the eye. The higher the magnifying power of the telescope employed, the more will the resulting imperfections of the image be rendered apparent.

Astronomers have long wished to seek a refuge from the imperfections of vision due to the ocean of atmosphere under which we live, and now that larger and larger instruments are being used, the necessity of at least palliating the evil becomes more and more apparent. We cannot ever hope to do without the atmosphere, or to observe for even half an hour outside of it, and live to bring back our observations; but we can get above the lower half of the air. With this end in view Piazzi Smyth went to the island of Teneriffe in the summer of 1856, and established himself at a height of 10,700 feet above the sea level. His experiences are described in a book which is, I believe, the first book that was illustrated by photographs. It is called "Teneriffe: an Astronomer's Experiment, or Specialities of a Residence above the Clouds," and gives a very glowing account of the advantages which may be obtained by an observer who could establish himself permanently at such an altitude, as well as a vivid description of the difficulties of getting adequate instruments up in addition to all the other things that are necessary to make an observer's life possible on the bare side of a volcano at such an altitude.

Sixteen years afterwards, in 1872, Professor C. A. Young took a 9½-inch telescope, and a large spectroscope with a dispersive force of twelve prisms of 60° to Sherman, a station on the Union Pacific Railway, 8,280 feet above the sea, situated at about the highest point which the railway reaches in crossing the Rocky Mountains. During a stay of less than two months he set up his instrument and observed 273 bright lines in the solar chromosphere. With the same instrument and spectroscope he had only been able to observe 103 lines in the chromosphere at Dartmouth College Observatory, and up to that date, as far as I am aware, only 28 lines had been observed in the chromosphere by observers in Europe (Secchi, Rayet, Janssen, and Lockyer). Professor Young therefore conclusively showed that a lofty observing station offered important advantages for spectroscopic observations of the sun's limb.

In 1876 Dr. Henry Draper took a small telescope with him to the Rocky Mountains and made a series of observations at altitudes varying from 4,500 to 11,000 feet, with the object of testing the observing conditions. On the Foot Hills and Alkili Plains he found the air very tremulous, at and near Salt Lake City it was not much better, but at a place along the North Fork of the Platte River in the main range of the Rocky Mountains, he found the seeing nearly perfect. He says, "Every defect of centering or of surface, and any vein in the glass came out even more clearly than in the workshop examinations, because while the air is as

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steady the light is far more intense. If a large telescope could be brought here and maintained against the furious winds great results might be attained."

In 1880 Professor S. P. Langley established himself for some weeks at the Casa del Bosco at an altitude of 4,200 feet on the south-east slope of Mount Etna. He had with him a small telescope and gave special attention to double stars and nebulæ with which he was familiar. His experiences as to the steady condition of the atmosphere were not satisfactory. In summing up his observations he says, "I should say that the gain on Etna over a lower station, as tried by the tests of a double star observer, was more in clearness of the atmosphere than in that freedom from tremor which accompanies good definition."

It would certainly not be worth while to establish an observatory at a great elevation for the sake of the increased brightness of the stars and nebulæ. For the absorption of light by the air is much less than is usually supposed. The thickness of air looked through is proportional to the secant of the zenith distance of the object observed. Professor E. C. Pickering has carefully observed the brightness of the same star at different altitudes as it rises or sets, and has conclusively shown from his observations that at the level of the sea, only about one quarter of the light of a star in the zenith is absorbed by the air. It follows from this that the brightness of a zenith star as seen from an observatory at an altitude of 13,050 feet (the height of the lower half of the atmosphere) would only be increased by a little more than one-tenth of a magnitude. But the upper air has less dust floating in it than the air at lower levels, and consequently the dispersion of light is greatly reduced, so that an object near the sun's limb, or a satellite or star near to the limb of a planet, would be much better seen at the higher altitude. This accounts for the great advantage which lofty stations afford for observing the lines of the chromosphere. I can to some extent personally vouch for this, as well as for the occasional great steadiness of the atmosphere as seen from an observatory at an altitude of a little over 1,000 feet. During the autumn of 1886 I visited M. Perrotin and M. Thollon, at the Nice Observatory, and watched the setting sun with M. Thollon on five clear evenings, to catch sight of the last blue ray—a phenomenon which is only seen at the sea level when the air is very still. As the sun sets it becomes redder and redder, till the limb is almost lost on the horizon, when suddenly, during a fraction of a second, the disappearing limb turns from a deep red to blue and vanishes. The obvious explanation is, that the blue images of the sun are more refracted than the red, and consequently the blue sun can be seen a little further round the earth's limb than the red; and though the light of the blue end of the spectrum is so dimmed by absorption that the whole sun appears red, there are still blue rays sufficiently bright to affect the eye, after the red rays have disappeared. The sun at that period of the year set over the bare edge of an opposite mountain, but on four out of the five nights I saw the blue ray, though I have only seen it on two other occasions from the sea-level.

Probably the most important factor in causing the steady images seen from the Lick Observatory is the sea fog or stratum of clouds which rolls in from the Pacific coast, eighty-seven miles distant, covering up the heated valleys and lowlands. This stratum of cloud, which seldom rises as high as the summit of Mount Hamilton, is shown in the upper picture on the second plate—where the sun is photographed setting, as it very frequently does, in the cloud stratum. Similar clouds covering the lower hills are also shown in the upper left-hand picture of the first plate. The stage coach comes daily to the door of the observatory, bringing provisions and letters, and weekly it brings a heavy freight of sightseers, whom Professor Holden receives for two or three hours into the working precincts, and seldom allows to go away without giving each a look through the great telescope, the eye-end of which is shown in the bottom left-hand picture of Plate 2. The bottom right-hand picture shows a part of the road up from San José, which is thirteen miles away as the crow flies, but is twenty-six miles distant along the winding coach road. The situation is most picturesque, though a continued residence at the observatory must have its drawbacks, for the wind not unfrequently blows at a rate of between seventy and eighty miles an hour, and the observers find it very cold even inside their substantial dwelling-house, shown below the observatory building in the picture above the winding road.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

NEBULOUS VARIABLE STARS.

To the Editor of Knowledge.

Sir,—In connection with the subject of variable stars I have looked over the observations made here during the last four years. The instrument in use is a $6\frac{4}{10}$ inch achromatic by Mertz, with powers 34, 80, and 132. Special attention has been paid to the telescopic images of the variables, and the general result of an examination of about thirty shows that most of them differ in a marked manner from ordinary stars in the same telescopic field. There is a general absence of the sharp stellar image ordinarily seen with a good telescope, and most of the variables present a more or less ill-defined nebulous image, somewhat suggestive of a naked-eye view of Mars in a misty sky. The following are from the observing-book:—

"S Cassiopeiæ, March 1, 1888: a conspicuous deep-red star; hazy, ill-defined as if surrounded by an atmosphere.

"R Cassiopeiæ, October 14, 1888: fiery red; there is a slight hazy look round this star as if seen through an atmosphere.

"V Cancri also occasionally presents this hazy appearance.

"S Coronæ: the star about maximum is clear and bright, but near minimum becomes lost in a nebulous cloud.

"S Cassiopeiæ: at maximum is hazy, nebulous, and ill-defined, but at minimum is 'minute and sharply defined.'

"R Cassiopeiæ: clear and well-defined both at maximum and minimum, but between the two phases it is often described as 'hazy and ill-defined as if seen through an atmosphere.'"

In all these observations special attention was given to the images of the companion stars in the same telescopic field, so as to leave no doubt as to the accuracy of the observations. The ruddy colour of most of the variable stars has long been noted. Among those under present observation the whitest are T Ursæ Majoris and S Herculis, which at times are almost colourless. The deepest red is S Cephei. R Cassiopeiæ is at times a most brilliant fiery red. The same star frequently varies much from time to time in depth of tint; while some, as T Ursæ Majoris, are palest at maximum, others, as R Serpentis, are deepest red at that phase.

C. E. Peek, M.A., F.R.A.S.

Rousdon Observatory, Lyme Regis:
March 14, 1889.

ABRAHAM SHARP'S SHORTHAND.

To the Editor of KNOWLEDGE.

DEAR SIR,—Herewith I send you the decipherment of the shorthand notes on the end of a letter from Flamsteed, of which a woodcut was given in the March number of KNOWLEDGE. It is an answer to Flamsteed's letter, and was written ten years later than the letters to Yarwell, of which I forwarded you a copy a few days back. The characters at times present some difficulties. Sharp was then in his sixty-third year. The taking of Preston by the King's troops was in November 1715; therefore the date of the letter, January 19, is in the year generally written 1715–16. The letter is without punctuation, and capitals are not indicated in shorthand, so that some of the sentences seem rather involved. Here and there, however, I have suggested capitals.—Yours faithfully,

JOHN WESTBY-GIBSON,
Past President of the Shorthand Society.

March 7, 1889.

[It is sincerely to be hoped that the owners of Abraham Sharp's MSS. will have all their shorthand documents deciphered and a longhand copy deposited in the British Museum or in the Library of the Astronomical Society. The intellectual events of the time of Flamsteed and Newton are so important, that any correspondence bearing upon them should be treasured and made available for public use.—EDITOR.]

ABRAHAM SHARP'S LETTER TO JOHN FLAMSTEED.

(*Deciphered from the woodcut of the specimen of his shorthand published in the last number of* KNOWLEDGE.)

Sr—Yours of the 11th past I received in due time but we have been so alarmed and terrified hearing of the Rebels disintegrating these parts these three or four weeks past who have been continually marching towards us and approaching so near as gave just occasion of fear they had a design against us especially considering all other parts were guarded with the King's soldiers whereas these parts were left utterly naked and ridiculously organised A multitude amongst us (some affirm two thirds of the inhabitants) and the greatest part of the gentry clergy and leading persons disaffected and ready to side with the rebels some of whom were not afraid to declare as much notwithstanding the engagements they are under by their oath lately taken of allegiance and fidelity to the King and present government and the violence whereof they seem not in the least to hesitate By this you may easily read what our apprehensions were and how little capable any sensible person could be of diverting his thought from so imminent a danger Nevertheless by the greatest Providence appearing for us in the defeat of the rebels at Preston (an account whereof no doubt you have had) our fears are in good measure dissipated and our minds more composed other common neighbourhoods may with more freedom and satisfaction be attended My first leisure I designed to employ in discharging as well as I am capable the obligations I stand under to you nevertheless for your last weeks letter, etc., though I have no more to offer but my hearty thanks for what you were pleased to communicate of your observations except hoping you carry them on still as all other parts of your business without any other hindrance or interposition than what results from common occurrences and infirmities of age and this is a privilege which we here have or ought to have already learned more highly to value even the exemption from such disturbances as for some time have put a full stop to trade and business as is the general complaint amongst us though it is hoped now there may be a little revival But I must allow I feel infirmities and indispositions creeping gradually on me being now in my grand climacteric so that I cannot bear those watchings and fatigues which formerly were not only easy but delightful to me I have been recently thinking of what you suggest viz instructing some person in the use of my instruments and engines but I find these matters are so little understood or valued in this country that I know not where to find any one either of a fit character for it or of intelligence to work These two instruments cannot be but of considerable value having within the space of the last ten or twelve years laid out on Mr. Yarwell while he followed the employment ten gu[ineas] or more in glasses for telescopes and telescopic sights for dec . . .* instruments Yet should I bestow them all gratis besides my labour in instructing I could not engage any person I know for work of ordinary intelligence or convenience to employ them to any good purpose therefore must be obliged to wait till some better encouragement be offered I hope however that your business proceeds successfully and approaches near to a desired period and application some notice whereof and of your health when your leisure and convenience permit will read the most acceptable news to

Sr Your most assured obliged friend and servant
Jan ye 19 1715 ABR SHARP

VIVISECTION.

To the Editor of KNOWLEDGE.

SIR,—It is of course very presumptuous on my part to question the assertions of Mr. A. J. Field on a subject wherein he is an expert and I practically ignorant. As your readers, however, will naturally accept his assurance in your current issue, that an antidote for viperine poison has been discovered and consequently deem my contention against snake-poison-experiments altogether fallacious, I beg respectfully to ask: "*Which* physiologist ought we of the unscientific public to trust in this matter?" The weight attaching to Mr. Field's name I am unable exactly to estimate, but I have always understood that the "Encyclopædia Britannica" constitutes a mine of reference in which all men may dig with confidence of finding the *dernier mot* of science. Now, in the last edition of that great work just completed (vol. xxii. p. 191, article "Snakes"), there occurs the following passage, which to my (unscientific) mind appears flatly to contradict Mr. Field's calm assurance to your readers that "an antidote *has been discovered* which is capable of coursing after and neutralising the poison of many viperine snakes":—

> Unfortunately no antidote is known capable of counteracting or neutralising the action of snake-poison. Some years ago injections of ammonia or liquor potassæ were recommended; but there is the obvious objection that hardly in one out of a thousand cases of snake-bite would either the appliance or the operator be at hand. Fayrer's experiments, however, have distinctly disproved the efficacy of this remedial measure. Equally useless is permanganate of potassium. . . . The remedy is entirely without effect after the poison has passed into the circulation. Treatment is therefore limited to endeavours to prevent, by mechanical means, the poison from entering the circulation; or by chemical agencies to destroy or remove as much of it as possible that remains in the wound.

Will Mr. Field not consent to inform your readers what is that antidote which he says "has been discovered" for viperine poison, but which remains unknown to the "Encyclopædia Britannica"?—I am, Sir, truly yours,

Hengwrt, Dolgelley: FRANCES POWER COBBE.
March 7.

P.S.—If you can spare me space, I shall be very glad to meet Mr. Field's main contention—that of the priority

* Declination.

of the claims of Science over those of humane feeling. He urges with moderation and guardedly, the argument from Nature's example which has been put forward successively by all the more thoughtful advocates of vivisection. I will only now remark that *if valid* its first result on human affairs must be a general reversion to Spartan infanticide. —F. P. C.

To the Editor of Knowledge.

Sir,—The gist of Miss Cobbe's letter would appear to be that an antidote has *not* been discovered for some of the poisons secreted by viperine snakes, the only evidence she brings forward for the substantiation of this rash statement being that the antidote is not mentioned in the "Encyclopædia Britannica."

Dr. Günther's article is an excellent one, but in the limited space of about ten and a half pages we can hardly expect it to be exhaustive. The whole volume, if devoted to the subject of snakes, or even snake-poisons, would hardly be sufficient. Dr. Günther naturally gives his attention to the more dangerous Indian species, for which I have stated before no antidote has yet been discovered.

Dr. Holford's method of injecting and applying ammonia to the wound is now extensively practised, and has proved very successful in the treatment of bites from the Australian species. Dr. Lacerda, one of Miss Cobbe's own witnesses, has recommended permanganate of potash as a remedy for the bite of the Horned Viper (*Cerastes*), which, according to his experiments, was invariably successful.

Fayrer's experiments were almost entirely confined to Indian snake-poisons, and therefore his remarks are generally in reference to Indian species. Ammonia, potassic permanganate, tannic acid, potassic hydrate, and various metallic salts have been applied successfully in cases of bites of the less virulent species of snakes.

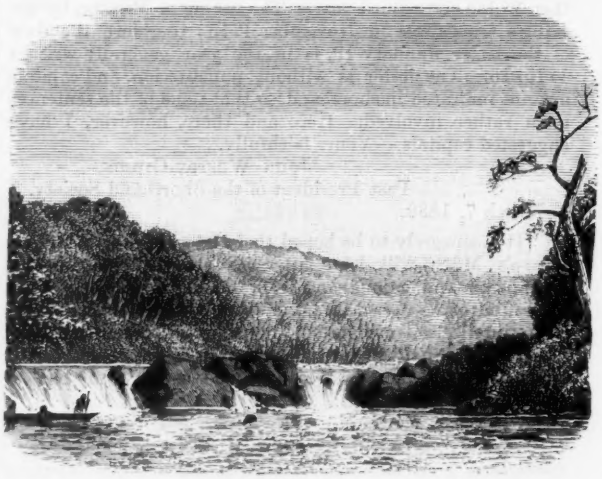
Olive oil is a remedy for the common adder (*P. berus*) and the asp (*Vipera aspis*). The efficiency of this remedy I have seen on several occasions practically demonstrated.

I know of no antidote that has proved of any value in the case of a bite from a cobra, a hamadryad, or a kerait. This has to be discovered.

Yours faithfully, A. J. Field.

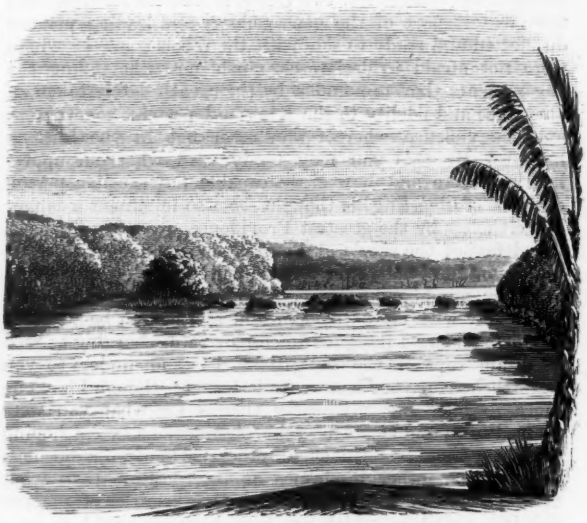
Notices of Books.

*Under the Lone Star.**—Although no wide areas of Africa remain untrodden by explorers, it abides the land of romance *par excellence* by an indefinable charm that no royal charters for the promotion of trade can dispel. When it ceases to be that, it will, at least so far as the equatorial parts are concerned, cease to interest. For, except perhaps in the regions watered by the Niger, there is little room for commercial development, since where there is small need or incentive to exertion, even the negro, if not "the roof and crown of things," may echo the Laureate's question and ask why life should all labour be? Still more pertinent is that question when the products of his toil and moil may fail to compete profitably with those of lands nearer the great markets of the world. The book under review records its author's experiences in Africa during the later years of his service in the Congo Free State, whose "lone star" flag he takes as sub-title. It does not, as might be inferred from the title, describe his climbing exploits, because the Kasaï is not a mountain, but one of the tributaries of the Congo, discovered by Livingstone, and descended by Wissmann. The expedition to which Captain Bateman was attached as second in command under Dr. Wolf had for its leading object the establishment of



Lulua Rapids.

a station at the confluence of the Lulua with the Luebo, both of which streams flow into the Kasaï, and it is the ascent of that river by steamer in accomplishment of this object which forms the main subject of the book. The narrative is told with straightforwardness and skill, but, so far as incident enlivens it, Captain Bateman is as story-less as Canning's Knife-



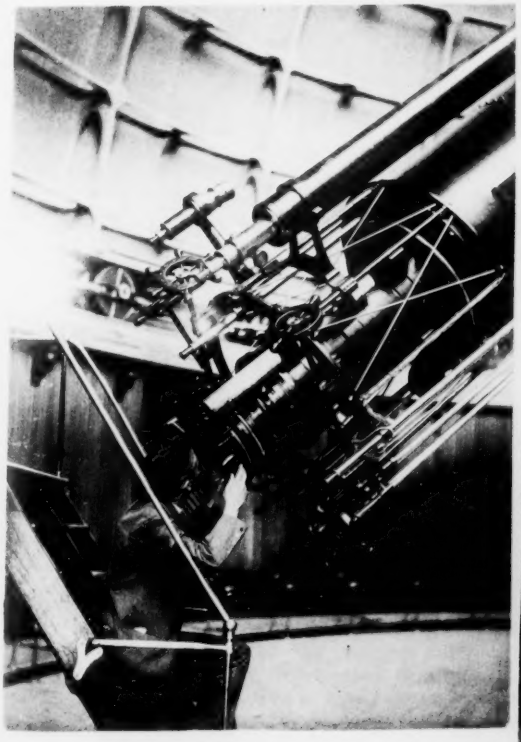
Falls of the Luebo.

grinder. Indeed, in the one excitement of the voyage he does not even play the rôle of "Friend of Humanity," since he felt in duty bound to effect reprisals on the

* "The First Ascent of the Kasaï; being some records of service under the Lone Star." By C. S. Latrobe Bateman, some time Captain and Adjutant of Gendarmerie in the Congo Free State. London: Geo. Philip & Son. 1889.

Sunset over
a Sea of Clouds.

Photograph from
Mount Hamilton



Eye end of 36-inch Refractor.

Observatory Buildings and Windmill.
The Coach Road up from San José.

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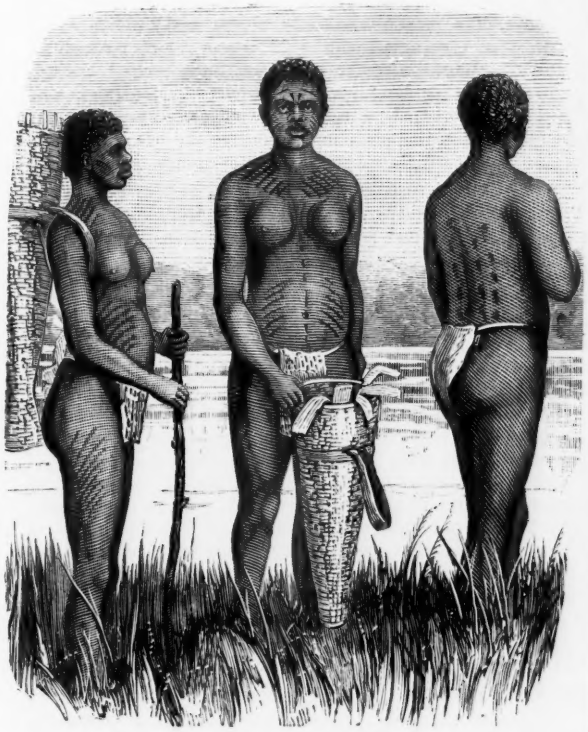
Basongo Meno for their treacherous attacks on Wissmann's party. So he looted and destroyed their settlement and burnt their canoes.

Later on he amuses us by the description of an eccentric chief who would in this country have received some claims to attention from Theosophists and their allies. Chilunga Meso saw visions and dreamed dreams, his claims being verified by the fulfilment of his prophecies. His manners were not agreeable, and his palaver with our author was prefaced by the antics of a man "possessed"—foamings at the mouth and continuous yelpings. He reminds us, although in an inferior way, of Bishop Callaway's Zulu friend Undayeni, one of those highly strung, nervous men whose organisation "appears to place them *en rapport* with the spirit-world, and to give them capacities of sympathy which are not possessed by common men," and "together



Basongo Meno Market Women.

with these powers comprehending the language of birds." * Senhor Caxavalla, the waggish interpreter of Captain Bateman's party, represented to Chilunga that he who devoted not his time to lonely contemplation would take a lower place in the life to come, and, pointing to an isolated rock-islet to which he pretended that it was his own practice to retire, induced Chilunga to consent to installation as the hermit of that rock. So the chief, exchanging his shako and Coldstream Guards' tunic for a cloak and chasuble made from an old sheet, and decorated with a number of charms, hied with his "superior" to the appointed rock one morning before sunrise. Caxavalla produced a book of Roman Catholic devotions, from which, making a random selection, he gabbled over a number of Latin and Portuguese words and sentences, the while Chilunga Meso, lean and scraggy, clothed in his cloak and decorated with the mystic charms, mounted to the highest pinnacle of the rock. "It is wonderful to me that the chief never suspected the impossibility of so hugely stout a man as the interpreter climbing in safety up and down so steep and slippery a place as the rocky islet, but certain it is that he did not, and that ever after Chilunga would retire to its solitude, sometimes for days together, believing that his experiences were deeper and his spiritual vision more clear upon that favoured islet than in his home amidst the lives of other men."

Senhora Caxavalla—a Portrait.

Among the more important races described are the Bashilangé Baluba, with their quasi-religious, freemasonlike organisation, named Lubuku, i.e. friendship, the rules, signs, and initiatory rites of which have never been disclosed to Europeans. In the central square of Kashia-Calemba, the capital, there burns a perpetual fire fed with logs, not by vestal virgins, but by decrepit men and women, who also prepare the "lhiamba" or bhang, which is smoked by the Lubuku in "kinsus" or pipes consisting of a clay bowl inserted in the larger end of a hollow gourd, the smaller end of which has a large opening, against which the smoker places his mouth, inhaling the smoke in great gulps. Lhiamba is smoked as a token of friendship, and also administered to accused persons as an ordeal. Accuser and accused smoke simultaneously in separate kinsus, the first to succumb to the baneful drug being declared guilty either of the crime or of false accusation. Captain Bateman discreetly refrains from attempting to define the exact significance of Lubuku; but when he says that it has no relation with the shamanism of the tribe he speaks without warrant. Indeed, both he and his clerical brother, who superintended this book through the press, have, we regret to find, the vaguest ideas possible concerning religion! In one sentence the Bashilangé-Baluba are spoken of as "in reality without a religion," while in the next sentence but one they are said to "believe in a future state, and possibly in the existence of One Supreme Spiritual Being, but have otherwise few, if any, theological theories" (pp. 114, 115). Further on the author gives evidence of their belief in metempsychosis in the fact that he was named "Chienvu," because he was deemed to be the embodiment of a chief of that name who had died some years previously (p. 159). Such looseness and confusion of ideas render the statements in this book on these matters valueless. The variety of illustrations which have been reproduced in colour, or etched and engraved, from the author's sketches, show him to be a skilful draughtsman, and they supplement somewhat unimpressive descriptions of the scenery through which the Kasaï flows, while a good map makes clear the route followed by the expedition.

Ed. Clodd.

* Callaway's "Zulu Tales," p. 130. (Natal, 1868.)

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Gleanings in Science. By Gerald Molloy. (Macmillan & Co. 1888.)—This volume consists of a series of popular lectures, for the most part in the theatre of the Royal Dublin Society, upon various subjects, such as the Modern Theory of Heat; Lightning, Thunder, and Lightning Conductors; the Storing of Electrical Energy; the Sun as a Storehouse of Energy; the Electric Light; and the Glaciers of the Alps. Some of these lectures were delivered as early as 1880, but the author, in preparing them for publication, has taken the opportunity of introducing whatever additional information has since been obtained. This is especially noticeable in the chapter on Lightning, to which is added a *résumé* of the objections of Professor Lodge to the Report of the Lightning Rod Conference, and of the discussion upon it at the British Association meeting at Bath last year. The first two lectures are devoted to Latent Heat—a subject that does not lend itself readily to popular exposition, especially when bereft of the striking experiments which were performed at the time of delivery, and for which the illustrations, good as they are in themselves, are but a poor substitute. We cannot refrain from taking exception to the loose way in which certain scientific terms are used. The use and abuse of scientific terms is no doubt a subject on which Dr. Molloy would himself feel strongly, but it is more than careless to write as he does on page 232, that "to reduce absolute units of energy to gravitation units, or foot-pounds, we must divide by the *force of gravity*, which in the British system of units is, in round numbers, 32." We are also a little surprised at his adopting the bastard unit, "Pound-Centigrade." Dr. Molloy seems to have an especial gift for devising lecture experiments. The lectures are written in a clear, concise, and interesting manner, the illustrations are good, and the type and paper help to make an attractive volume.

Practical Electrical Measurement. By James Swinburne. (H. Alabaster Gatehouse & Co. 1888.)—In this book, which is mainly a reprint of a series of articles that appeared in the *Electrical Review*, information is given as to the various methods of testing and the use and calibration of voltmeters, and other instruments to be found in the workshops of an electrical engineer. The instruments are somewhat critically discussed, and their merits and faults are pointed out. It is interesting to notice the wide difference in the limits of accuracy considered necessary by a physicist in his laboratory, and the approximations considered sufficient by an electrical engineer. The book has many good illustrations, and ought to meet with a large circulation among those for whom it is written.

ON SOME STRANGE FEATS OF CALCULATING BOYS.

By the late R. A. Proctor.

(*Continued from page* 64.)

SECONDLY, we may remember a passage by the mere sequence of words or sounds without reference (or, at least, without special reference) to the sense. This method may be called *verbal* or, preferably, *syllabic memory*. We are all of us more or less familiar with this kind of memory, even though we may not often, or perhaps ever, adopt this particular way of learning passages by heart. A passage learned otherwise, but often repeated after being learned, comes to be repeated in this manner.* But the point to be noted is that the power of learning syllabically—so to describe this method—is probably the true interpretation of the feats of memory which are commonly regarded as so astonishing, as indeed they are, though not in the sense in which they are usually apprehended. I have already referred in these pages † to a suggestion by Wendell Holmes, that this kind of memory might be regarded as a useful dynamometer, "which may yet find its place in education." It appears to me that the faculty is not more closely associated with true mental power than the faculty of recalling a tune which has been heard once or seldom. It is indeed a faculty of precisely the same kind, though it may well be that a person possessing one of these faculties may not always possess the other. If we rightly consider the case of a person who, having heard a long-continued sequence of notes forming an air or tune, is able to repeat the sequence correctly, we shall find it at least as remarkable as a case like that mentioned by Pepys, of a person who could repeat sixty unconnected words, or of the Indian who could repeat a long passage in Greek or Hebrew after it had been once recited, though ignorant of either language. It happens curiously enough that Paul Morphy, the chess-player, possesses in an unusual (though not actually phenomenal) degree the power referred to. In the work recording his achievements in chess, for instance, we find this passage:—"In the evening we went to the Opéra-Comique, and witnessed a very unsatisfactory performance of 'La Part du Diable.' Morphy has a great love for music, and his memory for any air he has once heard is astonishing. . . . 'La Part du Diable' was a new opera, yet Morphy, after leaving the theatre, hummed over many of the airs to me, which he had just heard for the first time, with astonishing precision." Of course the noteworthy point, here, is that Morphy is not a musician.

The third way in which a passage may be remembered is by the aid of a mental picture of the words forming the passage. After what we have seen of the achievements of Colburn, Morphy, and others, by means of the power of forming mental pictures, it need not surprise us if some persons can call up a mental picture of complete pages of letter-press, so that page after page may be mentally turned, as it were, and the words in them read off precisely as though the mental book were an objective reality. Nor is it at all improbable that this method of remembering series of words may explain some remarkable cases in which recited words have been repeated. We manifestly cannot explain in this way such a feat as the Indian's above men-

* It is indeed singular how retentive this kind of memory is. In saying this, I do not refer to the remembrance of familiar passages often repeated, for in reality such instances prove nothing; but there are cases where a passage learned in childhood, and not repeated for many successive years, is found not only to be retained as a passage having such and such a meaning, but syllabically, even with imperfections belonging to the time when it was learned. The following instance seems worth mentioning:—When about eight years old, and long before I began to learn Greek under proper tuition, I was led by childish ambition to con a Greek grammar belonging to a schoolfellow. My first step was naturally to learn the alphabet, and it so chanced that I took the ordinary pronunciation of every letter except "Chi," the "ch" in which I pronounced as in "child." The Greek grammar was soon dropped; and of course when the study of the language was entered upon, the usual pronunciation of "Chi" was indicated by the teacher. But though, perhaps, the Greek alphabet was not half a dozen times repeated in the old manner from that time for twenty or thirty years onwards, yet to this day, if I were to repeat the Greek alphabet while my thoughts were occupied with other matters, the wrong "chi" would come out. It is the same with several Latin words learned in France when I was still younger, and still pronounced in the French way, unless by an effort the English or the more correct Continental pronunciation be adopted.

† See the essay on the Growth and Decay of Mind.

tioned, or any case in which uneducated persons have repeated long series of words, for it is impossible for persons who cannot read to form mental pictures of words. But the case mentioned by Pepys can be explained in this way, and some of the feats of Pepys's memory-man can scarcely be explained otherwise. A man with a ready imagination can picture a word so printed as soon as it is uttered, and if several successive words are repeated, he will picture the series as clearly as though a page containing them were before his eyes. If he has a mental faculty corresponding to what Gustave Doré calls "collodion in the eye," the picture thus formed can be recalled at any time, and the whole series of words repeated. I have said that some feats can scarcely be otherwise explained. Pepys tells us that the prodigy he describes could repeat a series of recited words *backwards* almost or quite as readily as forwards. Here, then, there was no syllabic repetition. However perfectly we may recall a series of words by syllabic memory, it is not easy to repeat the words backwards, as any one (not troubled with the fears of being reputed a practiser of the evil art) can in a moment test by trying to repeat the Lord's Prayer backwards. Much less could any one repeat backwards a series of words only just learned by syllabic memory. No doubt the man whose feats so astonished Pepys possessed the power of picturing each word as a printed word as soon as it was uttered; and having thus formed in his mind's eye a complete picture of a long series of words, he could repeat them as readily backwards as though he were reading a series of words backwards from a book.*

Mental pictures may not only be formed in this way, but mental processes corresponding to particular actions may be carried on; and whatever the explanation may be, it is certain that skill in such actions may be acquired by such mere mental exercise. In some cases this is in no way remarkable. For instance, we can easily understand that when a passage is repeated mentally, the power of repeating it aloud may be acquired or increased. But it is different when the action to be acquired is strictly mechanical. It seems worth noticing, by those who make a special study of the brain and its powers, that a series of movements may be, as it were, *practised* mentally. For we are in the habit of regarding practised movements as acquired by associating certain mental processes with the actual performance of corresponding bodily actions, and it is not easy to explain, according to any known theory of cerebral action, how the association of mental processes with actions only conceived mentally can give skill resembling that derived from actual practice. Consider, for instance, one who is learning a piece of music for the piano, not having as yet acquired the art of immediately manipulating any indicated movement. We can understand how, by actually practising a difficult movement in the piece, such a learner can acquire the art of rendering it easily and effectively; for the theory of the brain tells us how certain muscles learn to respond in a particular way, and in proper time and sequence, to the messages conveyed by the visual nerves to the brain. But it is strange that when those muscles have not actually been exercised, but merely the idea of their use excited, the learner should yet acquire the art of using them in the required way.

Even more remarkable, however, is the fact that dexterity in particular processes is often inherited; nay, not only so, but sometimes, as it were, developed and intensified in the inheriting. We have hitherto not referred to the theory that some instances of wonderful mental power are to be explained by the doctrine of heredity. In fact, the instances we have been dealing with do not, so far as we know, illustrate that doctrine. Morphy's uncle is a strong chess-player, but not a fanatic for chess. Morphy's skill was shown, indeed, at an early age (when only twelve years old he won two games out of three, and drew the third, against Herr Löwenthal), but that point of itself is not sufficient to indicate *directly* inherited ability. Of Zerah Colburn's ancestry we know nothing. In passing, we may mention a circumstance which possibly may be connected with his phenomenal skill in elementary arithmetic. There is, or was, a family of Colburns, mentioned in the *American Popular Science Monthly* for November 1873, in which "the parents for four generations transmitted to the children what is called sex-digitism—i.e., hands and feet with six fingers each;" and considering the important part which the fingers play in the arithmetic of childhood, one can imagine that the young Colburns must have acquired unusual mastery over numbers. Not that six fingers on each hand would be at all convenient in numeration; but on the contrary, because learning the elements of arithmetic by the usual decimal system would be rendered more difficult, and the learner compelled to master arithmetical relations more thoroughly. However, we do not know even that Zerah Colburn was a member of this many-fingered family—and certainly he was not duodecimally fingered himself. It is noteworthy that, notwithstanding the antiquity of the science of numeration, the examples of skill hereditarily transmitted are much fewer than we might expect, especially when it is remembered that the sons of a mathematician have a better chance than others of receiving good mathematical training, and therefore a mathematical bias. Besides the nine Bernouillis, and the numerous Cassinis, Francis Galton has given a long list of families in which mathematical talent has seemed to be hereditary.

It is more striking with music, and perhaps with painting.* Heredity shows itself more markedly, it would seem, in the arts than in the sciences. Taking music, we find some remarkable instances. The Bach family, which took its rise in 1550 and became extinct in 1800, presents an unbroken series of musicians for nearly two centuries of that interval. The head of the family was Veit Bach, a baker of Presburg, and his two sons were the first of the family

* It is probable that some of my readers may not be aware of the use of this faculty of mental picturing, to recall forgotten words. For there are many who possess the faculty, but, never exercising it, remain ignorant of its existence. (Once recognised, the faculty may be greatly strengthened by use.) As a simple illustration of the useful exercise of this power, the writer cites a case which occurred a few days ago to himself. He was about to address a letter to a friend in the country, when he found that the most necessary part of the address had escaped his recollection. The name of the person, the name of the house, and the name of a large town near which was the park by which the house was situated were recalled, but the name of the park was forgotten, and as the writer was in a hurry to catch a particular post, of course the more the name was mentally hunted after, the less chance there was of recalling it. But his friend used note-paper with the address engraved in full upon it; and though none of his letters were at hand to show the address, it occurred to the writer that, on his forming a mental picture of the remembered part of the address, the forgotten word would appear in its proper and well-remembered place. This happened the moment the attempt was made. I would prefer not to say whether the letter was in time for post. It *might* have been, which is all the reader need care to know.

* In Titian's family we find the names of nine painters. The Caraccis, Teniers, Vanderveldes, Van Ostades, Hondekoeters, and others, will occur at once. Special methods of drawing and painting seem also to be inherited, not merely imitated. In the present writer's family the construction of large drawings in pen and ink (so as to have the appearance of engravings) has been a favourite employment of leisure time; and in the last three generations certainly the taste was not imitated, circumstances having prevented this. Thus, in the writer's own case, the taste first showed itself several years after the death of the parent from whom it was inherited.

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who were musicians by profession. The descendants literally "overran Thuringia, Saxony, and Franconia," says Papillon. "They were all organists, church singers, or what is called in Germany 'city musicians.' When they became too numerous to live all together, and the members of this family were scattered abroad, they resolved to meet once a year, on a stated day, with a view to keep up a sort of patriarchal bond of union. This custom was kept up until nearly the middle of the eighteenth century, and oftentimes more than 100 persons bearing the name of Bach, men, women, and children, were to be seen assembled. In the family are reckoned twenty-nine eminent musicians, and twenty-eight of a lower grade." Rossini's family played music at fairs; Beethoven's father and grandfather were musicians; Mozart's father was Second Capellmeister to the Prince-Bishop of Salzburg.

We are prepared, then, to find, in the theory of transmitted habits, the explanation of the wonderful musical powers of Mozart, with some account of which (from his Life by Holmes) we must close this note, already drawn far beyond the limits proposed when we began: "When Mozart's sister, then seven years old, was learning to play on the clavier (the early form of the piano), Mozart, then three years old, was a constant attendant on her lessons; and already showed, by his fondness for striking thirds, and pleasing his ear by the discovery of other harmonious intervals, a lively interest in music. At four, he could always retain in memory the brilliant solos in the concertos which he heard; and now his father began, half in sport, to give him lessons. The musical faculty seems to have been intuitive in him, for in learning to play he learned to compose at the same time; his own nature discovering to him some important secrets in melody, rhythm, symmetry, and the art of setting a bass. To learn a minuet, he required half an hour; for a longer piece, an hour; and having once mastered them, he played them with perfect neatness and in exact time. His progress was so great that at four years of age or earlier he composed little pieces, which his father wrote down for him." Later, "In music, he astonished his teacher, not so much by an avidity for information as by the impossibility of telling him anything that he did not know before. At the age of six Mozart knew the effect of sounds as represented by notes, and had overcome the difficulty of composing unaided by an instrument. Having commenced composition with recourse to the clavier, his powers in mental music constantly increased, and he soon imagined effects of which the original type existed only in his brain.

But in some respects perhaps the most remarkable circumstance related in this life of Mozart is the following. When he was only seven years old, his father took him to see an organ with pedals. "To amuse ourselves," says the father, in a letter to a friend, "I explained the pedals to Wolfgang. He began immediately, *stante pede*, to try them, pushed the stool back, and preluded standing and treading the bass, and really as if he had practised many months. Every one was astonished; this is a new gift of God, which many only attain after much labour."

To sum up—we perceive that the human mind is capable of forming pictures of processes, by following which mentally calculations of considerable complexity may be carried out, and other useful results obtained; we see that the mind can so perfectly picture some processes as to help in actually training the body by mere mental exercise; and lastly, we note that such powers, and even the accumulated results of long years of experience may in some cases be transmitted hereditarily. In these facts we may recognise interesting evidence respecting the possible future development of the human mind.

THE INFLUENCE OF CERTAIN DRUGS ON PHYSICAL STRENGTH AND ENDURANCE.

By T. Frederick Pearse, M.D., F.R.C.S.

THERE are certain drugs which have a great reputation for increasing physical endurance. These are chiefly coca, caffeine, and kola nut, and there are certain other chemical compounds of analogous composition which are derived from muscular tissue and have been found experimentally to have a similar effect. These are chiefly creatin and hypoxanthin. The chemical relation of all these substances is very interesting. Strange to say, some are themselves the products of muscular waste. It will be noticed also that creatin and hypoxanthin occur in beef tea, which is so well known as a general restorative and as a nervous stimulant, and there is ample experimental proof that it assists muscular power. The chemical relationship of the alkaloids found in tea, coffee, kola, and coca to the products of muscle-tissue metamorphosis suggests that these products are either replaced in the muscular tissue by these drugs, or that the products act on the nervous system either as a food or as a stimulant, and are merely supplemented in their action by the drugs. It is a very interesting question whether these alkaloids act locally on the muscle substance or upon the central nervous system.

As we know that tea, coffee, cocoa, and beef tea sustain and strengthen the nervous energies when they have been exhausted by other than prolonged muscular action, the inference is that these substances, as well as the analogous products of muscular tissue, act also directly as food or stimulant to the nervous centres. I have tested and found by experiment the powers of caffeine in increasing the respirations, and in strengthening as well as increasing the rapidity of the heart's action.

The following statements have been made by different writers as to the value of these substances.

Coca.—"Enables a greater amount of fatigue to be borne with less nourishment, and it lessens the difficulty of respiration in ascending mountain sides."—*Markham's Peruvian Bark.*

"The leaves are chewed to appease hunger and support strength in the absence of food, and used generally for the stimulant and narcotic effects of tobacco and alcohol."—*Practitioner.*

"It is of use to steady the nerves of excitable persons—to a sportsman in shooting, for example; to give endurance. It is used by travellers in Bolivia and Peru, to counteract the effect of rarefied air on mountains."—*Lancet.*

"In small doses it is said to lessen fatigue and enable the Indians in Peru to make long marches, and a similar result has been obtained in trials upon soldiers in Germany."—*Lauder Brunton.*

Experimentally, coca appears to act in small doses as a stimulant to the nervous system, affecting first of all the cerebral hemispheres, next the medulla, and lastly the spinal cord. It lessens the feeling of fatigue, but the only mental effect seems to be an exhilaration of spirits. Like caffeine, it increases the rapidity of the heart-beat and raises the blood pressure.

Caffeine.—Experimentally, caffeine has been found, in small doses, to quicken the respiration and also the pulse. It seems to affect the accelerating centre directly, as its action is equally well defined after the nerves have been divided. Besides increasing the rapidity of the heart's action it seems also to strengthen it, and it raises the blood pressure. Caffeine also seems to lessen tissue change and waste. In addition, caffeine appears to have some power in

paralysing the conducting power of the sensory parts of the spinal cord, and it may be in this way that it relieves the sense of fatigue. At the same time, however, it is found to increase generally the functional activity of the spinal cord.

"The peculiar wakefulness, the increased mental activity, and the often nervous restlessness which are induced by strong coffee are familiar to almost everyone. By doses of two or three grains of caffeine a very similar state of the body is induced. The increase of brain power which has been noticed by various observers after caffeine, as well as after coffee, tea, guarana, and all the allied crude drugs, is undoubtedly real, and must be due to a direct stimulant action on the cerebrum. It appears to me that the cerebral stimulation of caffeine differs from that of opium in that it affects the reasoning faculties at least as profoundly as it does the imagination. Coffee prepares for active work both mental and physical—opium rather for the reveries and dreams of the poets. The enormous use made by mankind of substances containing caffeine indicates that in some way it is directly of service in the wear and tear of life."—*H. C. Wood.*

Kola (*Sterculia acuminata*).—A native of Tropical Africa. The nuts from this tree are used to support the strength, allay the appetite, assuage thirst, and assist the digestion. They have also a reputation for increasing the capacity to bear prolonged fatigue.

The kola nuts contain a large percentage of the same chemical principle, theine, as is contained in tea and coffee. They also contain an aromatic volatile oil to which some of their properties must be attributed.

The seeds have been employed as a remedy for drunkenness, and they are said to abate the drink crave.

By virtue of the alkaloids, caffeine and theobromine, contained in kola, it must act as a cardiac tonic, improving both the force and rhythm of the heart.

The kola nut is slightly bitter and astringent, and its reputed value in digestive disturbances and diarrhœa may be based on these properties.

Phosphates.—Of all inorganic compounds these seem perhaps of the greatest importance in animal tissues. They are found in considerable quantity in the human body wherever active cell growth is going on. They must be ranked among the most valuable and necessary foods. Their acknowledged value in disorders of the nutritive system of children, and also in convalescence from acute as well as wasting diseases, in all of which rapid growth and tissue development is taking place, is good ground for the practical inference that they are intimately concerned in nutrition generally, and especially in the recuperation of parts worn out by disease. The recovery from prolonged and severe exertion also may very probably be assisted by them. The compounds of the meta-, pyro-, and hypophosphates in which the element phosphorus is loosely combined, seem much more efficacious than the ordinary salt.

According to Ashburton Thompson, repeated doses of phosphates improve the appetite, increase the rate of the circulation, sharpen the mental faculties, increase the muscular power, and give a sensation of well-being.

Creatin and Hypoxanthin.—These substances are said in small doses to have the power of increasing muscular work, and to cause the muscle to recover rapidly after exertion. Creatin particularly is said to have this power to a great extent. Glycogen is also classed with these substances, and is said to have great power of increasing muscular capability.

In practice, however, we all recognise a difference in the action of the popular mixtures—tea, coffee, cocoa, &c. In many persons tea will stimulate, and in a few it exercises a marked action on the kidneys and bladder. Coffee, again, will keep some people awake, while tea does not have the same effect with them. With some individuals it acts as a mild aperient. Coca does not seem to have any decided action on the digestive organs or kidneys.

We find, therefore, that the reputation for sustaining the strength, appeasing hunger, and temporarily increasing the physical powers which coca, kola, coffee, and tea have in the respective parts of the world in which they are indigenous is borne out by experiment. Moreover, there seems a probability that physiological science will shortly be able to provide a satisfactory explanation of the practical value of these substances.

THE FACE OF THE SKY FOR APRIL.

By Herbert Sadler, F.R.A.S.

ALTHOUGH the real minimum of sun-spots probably occurred some six months ago, yet the actual number of those visible on the solar surface with small telescopes increases very slowly indeed. Minima of Algol occur at 11h. 43m. on the evening of the 17th, and at 8h. 31m. on the evening of the 20th. A minimum of the Algol-type variable δ Libræ takes place at 17m. past midnight on the 29th. This star (R.A. 14h. 55m. 3s.$-8°$ 5′) varies from the 5th to below the 6th magnitude in 2d. 7h. 51m. 23s. The whole variation in the star's light is completed in twelve hours, the time from maximum to minimum being five and a half hours. A maximum of χ Cygni may be expected about the 17th. This remarkable variable (R.A. 19h. 46m. 18s. + 32° 38′) changes from about the 5th magnitude at maximum to absolute invisibility in moderate-sized telescopes at minimum in a period of about one year and six weeks. It is very red in colour, and lies between η and β Cygni, about one-third of the distance from η. This object must not be confounded with a 5th magnitude star, 17 Cygni, which lies about $1\frac{1}{4}°$ *n.p.* the variable. 17 Cygni can easily be identified in a small telescope by its having a reddish-blue star of the 8th magnitude at 26″ distance from it. Mercury is invisible, rising and setting as he does in bright daylight throughout the month. He comes into superior conjunction with the sun at 7h. A.M. on the 25th. Venus is a magnificent object in the evening sky for the first half of the month. On the 1st she sets at 10h. 28m. P.M., or 3h. 7m. after the sun, her apparent diameter being 42″. She is in Aries, but does not approach any naked-eye star very closely during the period of her visibility in April. On the 9th she is stationary, setting 2h. 34m. after the sun, and presents the appearance of a moon two and a half days' old, with an apparent diameter of 48″. After this she rapidly approaches the sun, becoming invisible to the naked eye soon after the middle of the month, the diameter of the planet getting larger and larger as the phase decreases. Two hours after midnight on April 30 she comes into inferior conjunction with the sun, and is then distant from us about $26\frac{1}{2}$ millions of miles. Mars is practically invisible, and Jupiter does not rise till after midnight on the last day of April, so that we defer an ephemeris of him till May. The minor planet Juno is still visible, and describes a short path in the western part of Virgo, but does not approach any naked-eye star very closely. On the 10th she souths at 10h. 36m. P.M. Saturn is still favourably placed for observation, and is nearly stationary during April in a portion of Cancer entirely barren of stars to the naked eye. At about half-past nine P.M. on the 6th Titan will be 53″ due north of Saturn; at midnight on the 15th Titan will be *s.f.* the planet, and Iapetus 37″ due north of it; on the evening of the 22nd Titan will again be 53″ north of the planet, and on the 30th

XUM

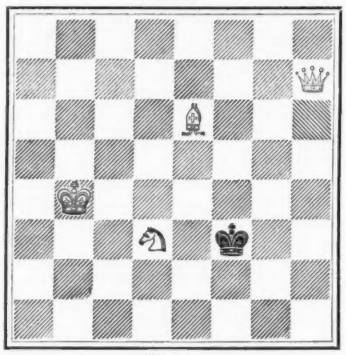
south of it. Saturn rises on the 1st at 40m. after noon, and on the 30th at 10h. 50m. in the morning, southing on those days at 8h. 20m. P.M. and 6h. 30m. respectively. Uranus is fairly well situated for observation, southing on the 1st at 32m. after midnight, and on the 30th at 10h. 35m. P.M., with a southern declination of about 7°. He describes a short path N.N.W. of Spica, but does not closely approach any naked-eye star. He is in opposition on the 9th, being then distant from us about 1,617 millions of miles. Neptune is invisible for the purposes of the amateur observer. April is fairly rich in shooting stars, the most noted shower being the Lyrids, connected probably with Comet I. 1861. They occur on the nights of April 19 and 20, and radiate from a point situated in R.A. xviii^{h} i^{m}.+33°, or not far from α Lyræ. The radiant point rises at 6h. 27m. P.M., and souths at 8m. past 4h. in the morning. The moon enters her first quarter at 1h. 47m. P.M. on the 8th, is full at 10h. 19m. P.M. on the 15th, enters her last quarter at 1h. 56m. P.M. on the 22nd, and is new at 2h. 5m. A.M. on the 30th. On the 4th the 4th magnitude star δ^{1} Tauri will disappear, at an angle from the lunar vertex of 117°, at 10h. 18m. P.M., and reappear, at an angle of 331°, at 11h. 9m., the star then being below the horizon at Greenwich; and at 10h. 59m. the same evening the 6th magnitude star δ^{3} Tauri will disappear at an angle of 73°, the star being on the horizon at the time, and will reappear at 11h. 25m. at an angle of 11°, the star being below the horizon. On the 5th the 5½ magnitude star B.A.C. 1563 will disappear at 6h. 37m. P.M. at an angle of 131°, and reappear at 7h. 53m. at an angle of 319°. On the 7th the 6th magnitude star, *d*, 36, Geminorum, will disappear at 8h. 58m. P.M., at an angle of 103°, and reappear at 10h. 4m. P.M. at an angle of 328°. On the 9th the 6½ magnitude star 35 Cancri will disappear at 8h. 50m. P.M., at an angle of 154°, and reappear at 9h. 52m. at an angle of 326°. On this evening and the early morning of the 10th the moon will pass across part of the scattered cluster Præsepe, the following two occultations and one near approach being predicted in the *Nautical Almanac*. ϵ Cancri, 6th magnitude, will disappear at 11h. 38m. P.M. on the 9th, at an angle of 154°, and reappear at 0h. 26m. A.M. on the 10th at an angle of 256°. This is a wide double star, the components being 6½ and 7 magnitudes, and the distance between them 134″. Both stars will be occulted. At 0h. 1m. A.M. on the 10th the 6½ magnitude star B.A.C. 2925 will disappear at an angle of 179°, and reappear at 0h. 28m. A.M. at an angle of 232°. There will be a near approach of the 6½ magnitude star 42 Cancri at 0h. 7m. A.M. on the 10th, at an angle of 205°. Many others of the 151 stars in this cluster whose positions have been determined will also be occulted, but the moon will be rather bright at the time, her age at midnight on the 9th being 9½ days. At 2h. 4m. A.M. on the 11th, the 6th magnitude star 8 Leonis will disappear at an angle of 151°, and reappear 43m. later at an angle of 251°; and at 7h. 9m. P.M. the same day the 6th magnitude star 37 Leonis will disappear at an angle of 15°, and reappear at 8h. 15m. P.M. at an angle of 271°. At 1h. 48m. A.M. on the 19th there will be a near approach of the 6½ magnitude star B.A.C. 5663 at an angle of 151°. At 4h. 34m. A.M. on the 20th the 6th magnitude star B.A.C. 6088 will disappear at an angle of 145°, and reappear at 5h. 17m. at an angle of 223°. At 0h. 10m A.M. on the 21st the 6th magnitude star B.A.C. 6448 will disappear at an angle of 79°, and reappear at 1h. 4m. at an angle of 200°. At 2h. 29m. A.M. on the 22nd there will be a near approach of the 6th magnitude star B.A.C. 6864 at an angle of 332°. At 3h. 11m. A.M. on the 22nd the 6½ magnitude star B.A.C. 6878 will disappear at an angle of 30°, and reappear at 4h. 7m. at an angle of 296°; and at 4h. 23m. A.M. on the 23rd the 5½ magnitude star η Capricorni will disappear at an angle of 124°, and reappear at 5h. 15m. A.M. at an angle of 221°.

Our Chess Column.

[Our Chess column has been placed in the hands of Mr. R. F. Fenton during the absence of Mr. Gunsberg, who has gone to play at the International Chess Tournament in New York. Mr. Gunsberg will probably return by the middle of May.—EDITOR.]

PROBLEM BY O. C. MÜLLER, LONDON.

BLACK.



WHITE.

White to play and mate in three moves.

THE STEINITZ-TCHIGORIN MATCH.

SEVENTH game of the series, played at the Casino Española, Havana, January 31, 1889:—

WHITE.	BLACK.
1. P to K4	1. P to K4
2. KKt to B3	2. QKt to B3
3. B to B4	3. B to B4
4. P to QKt4	4. B × P
5. P to B3	5. B to R4
6. Castles	6. Q to B3

The pertinacity with which Mr. Steinitz adheres to this novelty is remarkable; further practice and analysis may demonstrate its soundness, but in the present instance, as in the preceding examples, he early gets a constrained and difficult game, and even his ingenuity cannot extricate his pieces.

7. P to Q4	7. KKt to K2
8. B to KKt5	8. Q to Q3
9. P to Q5	9. Kt to Qsq
10. Q to R4	10. B to Kt3
11. Kt to R3	11. Q to Kt3

The *Times-Democrat*, to which we are indebted for this game, remarks that 11. P to QB3 appears least unfavourable, but then the following magnificent combination might have happened:—11. P to QB3; 12. QR to Qsq, P to B3; 13. P × P, Q × P; 14. Kt to Kt5, P × B; 15. Kt × KP, Q to B3; 16. Kt to Q6 (ch), K to B; 17. Q × QP, and wins.

12. B × Kt	12. K × B
13. KKt × P	13. Q to KB3

After this attack of White's upon the Queen, Herr Steinitz has a bad game to defend undoubtedly, but we can hardly agree with our contemporary "that Black's game may be considered lost," as he subsequently points out more than once how he might have retrieved the fortunes of the day.

14. KKt to B3	14. Q × P
15. P to K5	15. P to QB3

Perhaps R to Ksq was better.

16. P to Q6 (ch)	16. K to Bsq
17. B to Kt3	17. P to KR3

White's seventeenth move, a very good one, allows him to play his Queen over to his King's side, where she exercises a potent influence upon his opponent's undeveloped game.

18. Q to R4	18. P to Kt4

A very clever attempt of the champion's to divert the attack, but which is met with equal skill by Mr. Tchigorin.

19. Q to R5	19. Q to Q6

XUM

He now hopes to bring her majesty to the assistance of her beleaguered consort.

20. QR to Qsq	20. Q to R2

If, instead of attacking the Queen with the Rook, White had captured the King's Knight's Pawn, Black would have played his Queen to King's Bishop's Fourth with a winning advantage.

21. QKt to B3	21. K to Kt2

Herr Steinitz might here, apparently, have released his long imprisoned forces on the Queen's side by playing Bishop to QB4.

22. QKt to Q4	22. Q to Kt3
23. Q to Kt4	23. P to KR4

Trusting by this sacrifice of his extra Pawn to equalise the game—a manœuvre that might have succeeded against a less able antagonist—it has been suggested that he might, instead, have moved his Knight to King's Third; but in that case White, by checking with his Knight, and afterwards moving him to the King's seventh square, would retain a palpable superiority.

24. QKt to B5 (ch)	24. K to Bsq
25. Q × KtP	25. Q × Q
26. Kt × Q	26. P to R5

He might yet endeavour to liberate his game by playing here B to QB4.

27. K to Rsq	27. R to R4
28. P to B4	28. Kt to K3
29. P to Kt4	29. P × P *en pass.*

Retiring the Rook would have been better, for now Mr. Tchigorin finishes the game in a few powerful strokes.

30. QKt × KtP	30. R to R3
31. Kt × BP	31. K × Kt
32. P to B5	32. K to Ksq
33. P × Kt	33. P × P
34. Kt to K4	

And Black resigns.

For if 34. B to Q2; 35. Kt to B6 (ch); 35. K to Qsq. 36. Kt × B; 36. K × Kt. 37. RB7 (ch); 37. K to Ksq. 38. R to K7 (ch); 38. K to Qsq. 39. B × KP, and has an overwhelming advantage, and suppose 34. B to Qsq. 35. P to Q7 (ch); 35. B × P. 36. Kt to Q6 (ch); 36. K to K2. 37. R to B7 mate.

The match between Lancashire and Yorkshire was played on Saturday, the 9th inst., when twenty representatives from each county were opposed at the chequered board. It is to be regretted that neither side exhibited their full strength, as Liverpool objected to join in a match in which more than ten combatants were engaged on each side, whilst Yorkshire was without the services of the Hull and Huddersfield players. It is a pity that these two strong counties cannot come to some mutual arrangement, fair to both, and dependent, let us suggest, upon the number of players each can put in the field, so that the proportion of combatants shall not unduly press either side.

The Athenæum, Manchester, was the scene of the encounter, where the visitors were most cordially received by Mr. J. B. Rayner, the President of the Manchester Chess Club. Lancashire kept the lead up to seven o'clock, when the score was equalled by Yorkshire, each side having won seven games. At 7.15 play was discontinued, Yorkshire with eight wins and Lancashire seven wins. Five games were then unfinished, and these being handed over to the adjudicators, Messrs. Mills and Miniati (Lancashire) and Messrs. Cassel and Rayner (Yorkshire) left the final result with Lancashire eleven wins to nine wins for Yorkshire. After the match the visitors were entertained at dinner, when upwards of sixty gentlemen were present.

The great International New York Chess Tournament commences on the 25th inst. Our Mr. Gunsberg, accompanied by Mr. Blackburne, left Liverpool on Saturday, the 9th inst., on board the *Servia*. We hear Mr. Mason and Mr. Pollock are probable passengers also, whilst Mr. Bird will probably follow later. Some of the finest games will appear in our columns with notes.

We trust in our next issue to give the names of all the contestants. Mr. Steinitz is spoken of at present as a doubtful starter, but we hope he may be induced to compete.

Our Whist Column.

By W. MONTAGU GATTIE.

ANSWERS TO CORRESPONDENTS.

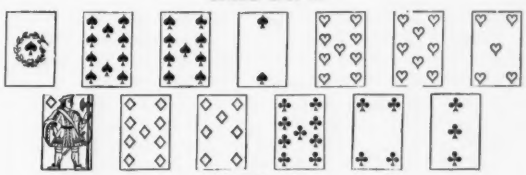
W. W. E.—1. With queen, knave, and one or more others, third hand should pass ten led. With queen, knave, only, he would have to play one of them, and would of course play the knave, unless he wished to call for trumps. In the case in question the ten was not passed, the queen being actually played to the trick. B's inference is merely that Y cannot hold the knave, for in such case he would have played it in preference to the queen.

2. It would have been more accurate to say that B's inference as to the position of the ace of trumps follows as soon as A has led to trick 5. If A had had the ace, he would have led it out, however many trumps he might hold.

EVERY ONE knows that it is the business of the man who holds a strong trump hand to lose no time in drawing the adversaries' trumps with a view to making as many tricks as possible in his own or his partner's longest plain suit. Now, the fortunate possessor of, say, five or six trumps can hardly expect to have a long plain suit also; he must, in most cases, look to his partner for assistance in this respect; and, when he again obtains the lead after exhausting the adverse trumps, he has, in the first place, to ascertain (if he does not know already) what his partner's suit may be, then to assist him to establish it by playing or drawing out commanding cards in it, and finally to throw the lead into his hand. If the partner has had an original lead it may nearly always be assumed that he has led from his longest suit; and, even if he has not yet had a lead, he can often give a sufficient indication by his discards what his long suit is. But, even though there be no doubt on this point, and though the suit be established to boot, it not seldom happens that the player who is strong in trumps is very short in his partner's suit. The hand published in the March number of KNOWLEDGE furnishes an instance of the importance, under such circumstances, of husbanding a single card of the suit, until the proper moment arrives for leading it out. Greater difficulty arises when the strong trump hand is left with no card at all of the partner's long suit, and has no direct means of putting the lead into his hand. Clearly the suit will be of little use unless the partner holds a card in some other suit, whereby he can obtain the lead. If this card be an ace, or some other card which is certain to win a trick, he will, no doubt, sooner or later, bring in his suit; but it may be that he has only a doubtful card of re-entry (*e.g.* second or third best guarded), and in that event it becomes incumbent on the strong hand to fortify the doubtful card as much as possible by endeavouring to disarm the opponents in that suit also. With this view, the highest should generally be led, even from a suit of four cards or more; for if it be, for instance, the queen, it may draw the adverse ace, and, supposing the partner to hold the king, he will in this way be provided with a certain means of bringing in his long cards.

This point is illustrated by the following game, in which B endeavours to place the lead in his partner's hand by the method we have indicated. His design, however, is fathomed and defeated by Y.

HAND No. 3.



Y's Hand.

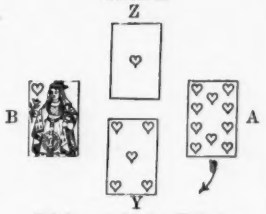
Score—Love all.

Z turns up the 10 of diamonds.

NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

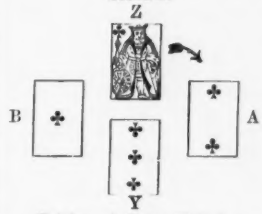
The notes appended to the tricks are supposed to be made *during the play* by the player whose hand is exposed. General remarks on the play follow at the end of the hand.

Trick 1.



Tricks—A B, 0; Y Z, 1.

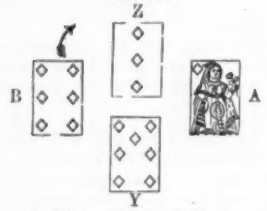
Trick 2.



Tricks—A B, 1; Y Z, 1.

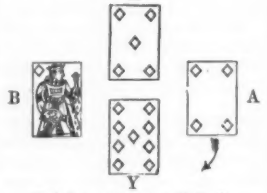
NOTE.—*Trick* 1.—A has probably led from king, knave, ten, in which case his suit is already established.

Trick 3.



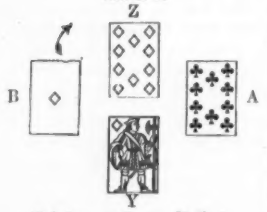
Tricks—A B, 2; Y Z, 1.

Trick 4.



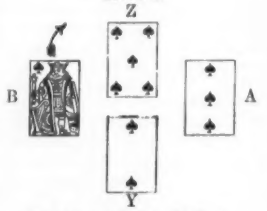
Tricks—A B, 3; Y Z, 1.

Trick 5.



Tricks—A B, 4; Y Z, 1.

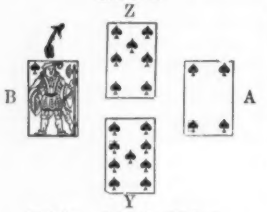
Trick 6.



Tricks—A B, 5; Y Z, 1.

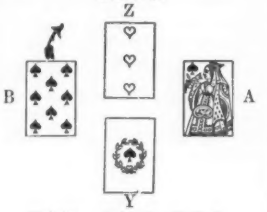
NOTE.—*Trick* 5.—A's discard shows that he has no more clubs; for he cannot have anything smaller than the ten; the queen is marked in Z's hand; and if A had held the knave he would have kept it guarded. It is now certain that A has a strong established suit of hearts. Probably he is also carefully guarding a card of re-entry in spades. *Trick* 6.—A B want five more tricks to make game, and B has the two remaining trumps. Clearly he would win the game easily by leading hearts, and, as he does not do so, it must be assumed that he is void, and is endeavouring to fortify whatever card of re-entry A may possess in spades. Y determines to defeat this manœuvre by holding up his ace.

Trick 7.



Tricks—A B, 6; Y Z, 1.

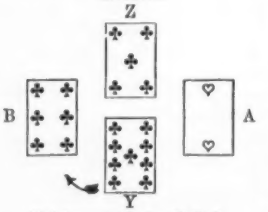
Trick 8.



Tricks—A B, 6; Y Z, 2.

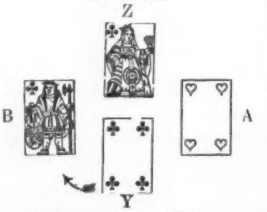
NOTE.—*Trick* 7.—B continues the attack with his knave, and Y still refuses to part with his ace.

Trick 9.



Tricks—A B, 6; Y Z, 3.

Trick 10.



Tricks—A B, 6; Y Z, 4.

NOTE.—*Trick* 9.—As the cards happen to lie it makes no difference whether B leads the ten of spades or the nine of clubs at this point. But he cannot be certain whether the six of spades is with B or A; and in the latter case B would trump the ten, and then lead a club. Now, if this club should be a small one (say the six). Z, with queen, eight, five, or even with queen, knave, five, should pass the trick, for the game could not be saved if Z should have to lead up to B. But not every partner can be expected to play so well as this; and by leading out the club Y saves Z the chance of making a mistake, while the ten of spades is sure to make some time or other if B hold the six. Of course, if B hold knave, eight, of clubs, YZ cannot save the game in any way.

Tricks 11 to 13.

Z continues the clubs. B trumps and leads trump, and then leads his losing spade, which Y wins with the ten; and

A B SCORE TWO BY CARDS AND TWO BY HONOURS.

A's Hand.	B's Hand.	Y's Hand.	Z's Hand.
D.—Q, 4.	D.—Ace, Kg, 8, 6, 2.	D.—Kn, 9, 7.	D.—10, 5, 3.
C.—10, 2.	C.—Ace, Kn, 6.	C.—9, 4, 3.	C.—Kg, Q, 8, 7, 5.
H.—Kg, Kn, 10, 7, 4, 2.	H.—Qn.	H.—9, 8, 5.	H.—Ace, 6, 3.
S.—Qn, 4, 3	S.—Kg, Kn, 8, 6.	S.—Ace, 10, 9, 2.	S.—7, 5.

Remarks.—Trick 2.—B would have won the game if he had held up his ace of clubs; but he was naturally anxious to get in to lead trumps, and he could not be sure that any delay in doing so would not enable Y to make a small trump on the second round of clubs. *Trick* 5.—A's discard is fatal: the question is whether it is also bad. He cannot spare a spade, so that the only alternative seems to discard from his strong suit, and by so doing he might lead his partner to imagine that his original lead was from weakness. Nevertheless, we should have preferred to discard a heart, and run the risk of our partner's expostulations at the end of the hand. *Trick* 6.—B plays well in leading the king to save his partner's hand. Although B holds four spades, he cannot expect to make more than two tricks in the suit; and, since he cannot depend on his knave of clubs, he must look to A for the one other trick needed to secure the game.

ELEMENTARY EXPLANATION OF THE PLAY.

Trick 1.—A leads the ten, which is the proper lead from king, knave, ten, &c. The ten is often spoken of as a "doubtful card," for it sometimes turns out to be the best of a three-card suit, which the leader may have found it desirable to open instead of his long suit.

Trick 2.—Z leads king from king, queen, in order to clear the suit by bringing out the ace. Compare Hand No. 1, trick 4, and Hand No. 2, trick 1. If the king had made, Z would have continued with a small card, assuming his partner to hold the ace. Y of course infers that Z has the queen, and at least two other clubs.

Trick 3.—Having five trumps, with two honours, B rightly leads them. In plain suits, the king should be led from ace, king; but in trumps it is usual to lead a small one unless the leader has six or seven in all. His own ace and king are certain tricks, and he gives his partner a chance of making queen or knave, if he should hold either.

Trick 4.—A follows the almost invariable rule that a partner's lead of trumps should be returned at the first opportunity. Compare Hand No. 2, trick 5.

Trick 5.—AB have now shown "two by honours," and every one of the four players should at once recognise that YZ must make five tricks to save the game. A follows the rule in discarding from his weakest suit. The student should follow carefully the effect which this discard has upon the game, as indicated in the notes given above.

Tricks 6 *to* 8 are sufficiently explained in the foregoing notes. B does all he can to enable his partner to get the lead and bring in his hearts, but he is out-manœuvred by Y.

Trick 9.—It being known from trick 5 that A is void of clubs, Z is able to finesse the 9, so that B's knave is hopelessly beleaguered. Note that Y follows the rule—in this instance obviously imperative—of returning the *highest* of *two* remaining cards of his partner's suit.

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